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ORIGINAL MEMOIRS

CONGENITAL INTERNAL HYDROCEPHALUS.*

ITS TREATMENT BY DRAINAGE OF THE CISTERNA MAGNA INTO THE CRANIAL SINUSES.

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PART I.

A. INTRODUCTION.

IN a paper upon the "Surgical Treatment of Meningitis" [1] read by invitation at the annual meeting of the American Laryngological, Rhinological, and Otological Society, at Philadelphia, May 14, 1912, it was suggested that the operation of drainage of the cisterna magna, which had been advocated by the writer for the treatment of meningitis, might also be advantageously utilized in the treatment of hydrocephalus.

In making that statement, that form of this disease resulting from an attack of basilar inflammation which had blocked up the outlets of the fourth ventricle, especially the foramen of Magendie, was chiefly considered.

On June 4, 1912, at the invitation of Drs. Pisek and Peterson, the writer operated at the Post-Graduate Hospital for congenital internal hydrocephalus by the method herein described, of drainage of the cisterna magna to the surface.

* Read before the New York Surgical Society, January 8, 1913.

The result was unfavorable—the infant died from too free escape of the cerebrospinal fluid. In October last, a second case of this type was referred to me by Dr. Pisek. A review of the literature on surgical interference in these cases showed that in all the plans proposed there were no curative promises. The cases all terminated fatally sooner or later, and the exceptional recovery obtained at infrequent intervals might as well be credited to spontaneous cure as to the surgical interference. After considering the question of hydrocephalus in its various aspects, the conclusion was reached that the best place to drain off the hydrocephalic fluid was into the cranial sinuses and that this drainage should take place from the cisterna magna. The technic of its accomplishment is detailed in the case reports. The operation was successful in that drainage was established into the occipital sinus. This channel functionated for three weeks and then gradually closed.

Further, search of the literature disclosed that while this plan of draining the cerebrospinal fluid from the great cistern into the cranial sinuses seemed to be original with the writer, Gärtner,[2] in 1895, had asked if it were not possible to establish a communication between the hydrocephalic cavity and the lymphatic or venous systems through a sinus or a vein of the head, and that Payr,[3] in 1908, announced a method of uniting the lateral ventricle with the superior longitudinal sinus by means of a piece of the long saphenous vein. This operation will be reviewed at length, also the one of Bier,[3] of drainage of the same ventricle by means of the temporal vein.

Though antedated by Gärtner in the basic conception of this operation, and by Payr in an attempt to accomplish it, and notwithstanding the fact that the appended observations are based on the same facts and theories as his, the writer feels that it is justifiable to present a method of its accomplishment which seems much simpler in the technic of its execution.

B. CASE REPORTS AND TECHNIC.

Drainage of the cisterna magna into a cranial sinus for congenital internal hydrocephalus. Recovery from the operation, much improvement for four weeks, return of original state, but

in lesser degree, infant living at date of this writing, December 27, 1912, in miserable general condition, apparently suffering from severe marasmus. (See Addendum.)

CASE I.—H. M., male, aged six months. Admitted to the Red Cross Hospital, October 19, 1912. Referred to the writer by Dr. G. R. Pisek.

At birth child appeared normal. Six weeks after birth head began to enlarge, and has continued ever since. When nine weeks of age ventricular puncture was performed at the New York Post-Graduate Hospital, and this or lumbar puncture has been repeated five times since, from 2 to 2½ ounces of clear fluid being removed at each puncture, but without any permanent improvement.

Condition.—There is a marked degree of hydrocephalus; the child cannot move its head on the pillow. There is the convergent downward squint. The face is thin and weazened, the body emaciated. The arms are flexed and the hands clinched. The child whines continuously.

Operation (October 22, 1912).—Ether-vapor anæsthesia by Dr. Lumbard. Dr. Boynton and the House Staff assisting.

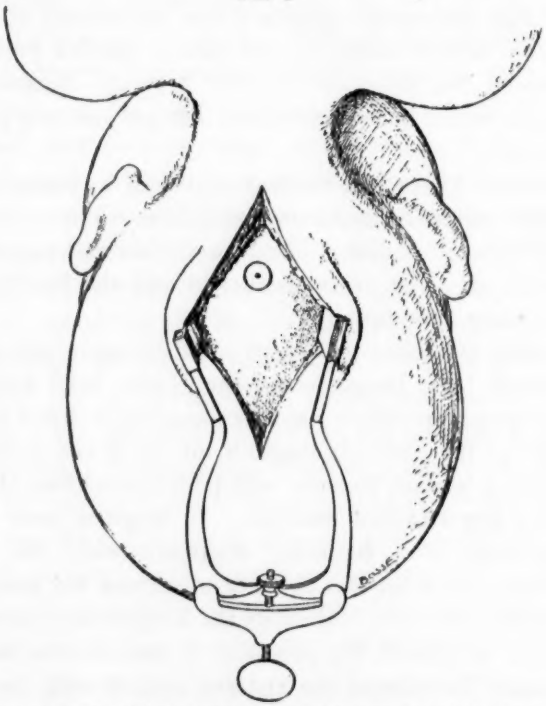
The proposed operation was to expose the occipital bone from the margin of the foramen magnum to above the occipital protuberance by a median incision with lateral reflection of the periosteum and the attached muscles. To trephine over the midpoint between the foramen magnum and the occipital protuberance, and from this opening to remove the bone upward so as to expose the termination of the longitudinal sinus. With a manometer to record the pressure in the cisterna magna and in the sinus. To connect the cisterna magna with the occipital sinus if it showed large enough or with the torcular, by means of a rubber tube having an internal diameter of 1.5 mm., and to suture it in place, the tube, silk, and needles having been previously sterilized in vaseline. The tube was to be let into the cistern and sinus through minute incisions that would be completely filled by the tube, which, for this purpose, had firm resisting walls. To complete the operation by closure of the soft parts after packing the débris of bone in the gap in the skull.

The tubes are of firm consistency, with an internal diameter of from 1.5 to 2 mm., and varying in length from ¾ to 1 inch.

The shorter the tube the better. That rubber tubes and needles and silk sutures may be used in and about the vessels without clotting of blood has been too well established by Carrell [4] and others to need further mention.

The tube is prepared by being cut across obliquely and the sutures threaded through the ends as shown in the diagram. The object of the suture is to quickly pull the tube into the

FIG. 1



Median incision, retraction of periosteum and muscles, exposure of the bone, and position of the trephine opening.

incision in the dura and fasten it there when in place. The tapering is to facilitate this procedure. The needles are the fish-hook pattern of Mayo. One is passed through both dura and arachnoid (which in this condition is pressed against the dura) so as to traverse the cisterna for a quarter of an inch, the other in a similar manner is passed through the occipital sinus or torcular. Before each needle is withdrawn, alongside of it is thrust a narrow knife about ⅛ of an inch wide to make

a tiny vertical cut in the membranes. The knife is withdrawn, the needle pulled through with the suture and tube attached, and the latter is pushed into the incision, filling it up. The tube is then tied in place. It should be compressed lightly to stop the flow of fluid through it. The technic is carried out on the side of the sinus. A sufficiently tight fit should be planned between tube and incision, so that the former shall be compressed by the membrane. After a little while, by its own elasticity the tube will expand and fluid flow through it. If considerable cerebrospinal fluid should have been lost during the operation, the pressure should be restored by following Keen's suggestion under similar conditions and inject into the cisterna magna a sufficient quantity of saline solution to make up for the loss.

The operative attempt upon the patient only followed the first few steps. The bone was easily bared and the oozing checked by hot compresses. A trephine was applied as planned. It was ¾ of an inch in diameter. Notwithstanding an appreciation of the thinness of the bone and its softness, and while using most careful manipulation, on removing the trephine there was a gush of clear fluid from the lower half of the trephine cut and it was obvious that the trephine had gone through bone, dura, and arachnoid and opened the cisterna magna. It was therefore necessary to tightly close up the incision at once, so that death might not ensue from too sudden loss of fluid, which was done.

Course of the Case.—The child did not die. Its fontanelles began to retract slowly. At the end of three days there was a distinct cavity over them. The child's general condition began to improve, and it was discharged from the hospital November 2. This improvement continued for three weeks longer, when the original symptoms gradually returned. The betterment in the child's condition may be explained in that the occipital sinus was severed by the coarse trephine and into it flowed the excess of cerebrospinal fluid, until later its opening gradually closed by a healing process and the fluid again began to collect in the intracranial spaces.

It might be said that the loss of fluid at the operation was responsible for the change. However, the opening in the skull was tightly closed at once by the finger and held thus until all

the sutures were in place and all but two tied, when external pressure through the scalp effectually prevented any more loss of fluid. There was no drainage from the wound into the dressings, nor into the subcutaneous tissues.

December 11 ventricular puncture was done and 2½ ounces of fluid removed. The benefit following this relief of pressure only lasted for a few days.

December 26, the child's condition was hopeless. Beside the hydrocephalus, the child shows advanced marasmus. When the child was first admitted to the hospital the mother's milk was tested and found to contain less than 1½ per cent. of fat. Artificial feeding was begun but has not accomplished anything.

CASE II.—G. B., female, aged six months. Admitted to the Red Cross Hospital, December 9, 1912. Referred to the writer by Dr. I. S. Tunick.

The child was apparently normal at birth. Six days after birth the infant's right hand was pricked by a pin, infection followed, and after two weeks the baby's hand was operated upon. Four weeks later an attack of erysipelas began which lasted two weeks. Three weeks after this, or when 13 weeks old, the baby had convulsions attended with a rectal temperature of 104°. No diagnosis was made, but from this time the head began to enlarge. Up to the present, lumbar puncture has been performed six times with removal of from 2 to 2½ ounces at each puncture.

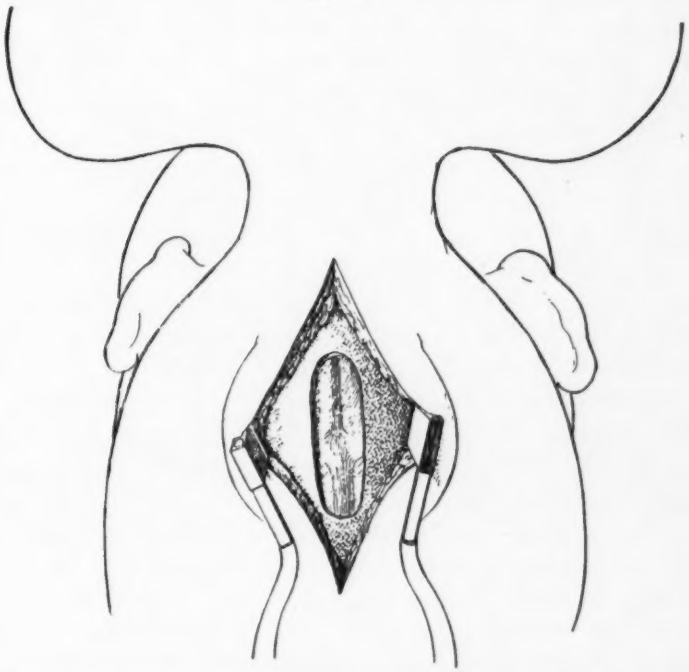
This infant, while having a very large head that it could not lift or move, was a very much more promising subject than the preceding one. Its general nutrition was much better, and it did not have the marked eye, nervous, and mental symptoms of the first case. In order that a communication between the two spaces might be established by a method easier and simpler than the one just given it was decided to use a silver cannula with obliquely sharpened ends, bent on a short curve to a right angle (see note).

It was to be used in this manner. The cisterna magna and the occipital sinus (or the torcular if necessary) were to be

NOTE.—The cannula had an internal diameter of 1½ mm. Its long arm was 1 inch and its short arm ¼ inch. They were bent on a short curve to stand at right angles to each other.

exposed. The pressure in the cistern and sinus was to be taken. Then the long end of the vaseline-sterilized tube was to be passed into the sinus and the other end thrust through the membranes into the cistern. This would unite the two spaces. The tube was to be held in place by a suture. Hemorrhage was to be controlled by pressure of hot sponges. Loss of cerebro-

FIG. 2.



The bone has been removed to show the dura over the cisterna magna and the confluence of the sinuses.

spinal fluid was to be prevented by digital pressure or by a purse-string suture about the tube, and any considerable loss made up by infusion of normal salt solution. The skin was to be tightly closed.

Course of the Operation (December 11, 1912).—Ether-vapor anæsthesia by Dr. Lumbard, Dr. Moorhead and House Staff assisting. An incision, two inches long, was made in the middle line with its centre over the occipital protuberance. The periosteum with the muscles was reflected. A right parietal emissary

vein was torn across and bled freely, but was easily controlled by finger pressure. A small ⅜ inch trephine was applied midway between the protuberance and the margin of the foramen magnum and a thin button of bone removed. The dura bulged into this small opening. The intracranial pressure of the cerebrospinal fluid was now taken and showed a record of 75 cm. in vertical height. The pressure in the sinus was not taken, as I determined to utilize the parietal emissary vein for drainage purposes and did not care to prolong the operation merely to uncover the sinus and get its pressure. The long arm of the silver cannula was slightly bent so as to easily enter the emissary foramen, into which it was placed, and the other end pushed through the dura and arachnoid into the cisterna magna. The cannula was held in that position until the skin sutures were placed and tied and a firm dressing applied to the surface. The child was in fine shape when taken from the room.

Course of the Case.—There was considerable loss of cerebrospinal fluid through the incision between the sutures for the first 24 hours. However, as everything seemed to be progressing nicely nothing was done to prevent it. On the thirteenth the wound was dressed. The flow of fluid was only small in amount from one end of the incision. This was checked by firm strapping. Nothing more was attempted, as the child appeared to be doing exceptionally well. During the following night it gradually became worse and by morning had a temperature of 106° F. From this time on until evening it became worse and died at 9 P.M. of the 14th, the cause of death, evidently, being due to a too rapid loss of fluid to the surface. This loss of fluid was apparent from the first, but the child was so well during the first 24 hours, and the flow of fluid seemed so little during the second 24 hours, that when too late to do anything it was realized that it had had its effect in determining a fatal ending.

Autopsy, only examination of the wound was permitted. There were no inflammatory evidences anywhere. There was no blood in the cisterna magna. It contained only a very little fluid. The lower end of the cannula had been displaced from the dural opening, but the upper end was in the emissary foramen. Its lumen was closed by a clot that did not reach to either end but seemed to be only at the angle.

Inferences: The tube should have been held in place by a suture in the dura. That a clot formed in it must have been due to insufficient preparation.

Part II.

A. Physiology of the Normal Intracranial Circulation; the Formation and Disposition of the Cerebrospinal Fluid.

In order to understand the facts and theories upon which the preceding operation is based, it is necessary to briefly review the conditions which prevail in the normal intracranial circulation and its attending phenomena.

The arterial blood supply to the brain is exceedingly free and is in direct relation to the heart without the intervention of any considerable turns or angles. The brain feels alterations in heart pressure very quickly and with small diminution of force. The blood is furnished to the brain by a mechanism designed to give it the maximum quantity, continuously and freely distributed. Especially is the blood supply to the choroid plexuses of the various ventricles so arranged as to guarantee at all times a free current of fresh arterial blood.

The venous return from the brain is by means of the various cerebral veins, which, grouped into two systems, pass to the cranial sinuses. The internal venous system eventually terminates in the straight sinus, while the surface veins end in the superior longitudinal sinus, chiefly. Beside these chief terminal outlets there are some other ones which are not necessary for our consideration.

Mention should be made of the mechanism which nature has provided at the base of the brain, the jugular bulb, which

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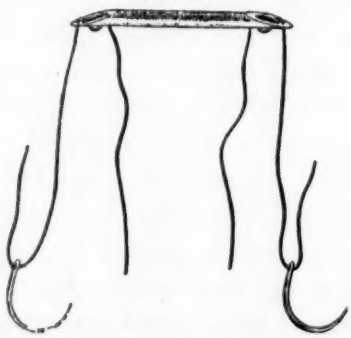
Note.—"Exudate. Any adventitious substance deposited in or upon a tissue by a vital process or disease. Adventitious, accidental or acquired, not natural; not natural or hereditary; found out of the normal or usual place."

"Transudate. Any substance which has passed through a membrane."

is a veritable "plumber's trap" (Macewen[8]). By this method of construction a steady flow of blood is assured from the brain by the conversion of the pulsating arterial stream into a steady venous current.

Beside these mechanical arrangements to equalize the intracranial pressure, the cerebrospinal fluid exercises a very important part. This fluid is a true secretion furnished by the gland-like cells of the ependyma covering the choroid plexuses. It is not lymph. It is not an exudate or a transudate. Its quantity is only enough to lubricate the

FIG. 3.



Enlarged drawing of the rubber tube to show the manner in which it is cut and the sutures attached. The actual tube is 1.5 to 2 mm. in internal diameter and in length to correspond to the space to be traversed. The shorter it is the better. Its length will be from three-fourths of an inch to twice this.

membranes between which the brain is enclosed and permit free movement in a limited degree. It varies in quantity from 60 to 80 c.c. (Howell[9]). Its course is from the lateral ventricles, through the foramina of Monro, the third ventricle, the aqueduct of Sylvius, the fourth ventricle, and the foramina of Key and Retzius, and especially the foramen of Magendie into the basilar subarachnoid space, the cisterna magna. After filling the spinal canal, the cerebrospinal fluid courses upward over the surface of the brain to enter the superior longitudinal sinus. There are some other sinuses into which the fluid passes, but they may be disregarded in this review. There is another way in which the fluid may leave the skull under exceptional conditions, viz., by way of the lymphatics.

However, as the cerebrospinal fluid is not lymph, its passage into the lymphatics even when under great pressure is almost *nil.* In the normal state this passage does not take place. In the child after the age of three years and thereafter the passage of the cerebrospinal fluid into the cranial sinuses is chiefly by means of the Pacchionian bodies. While the action of these bodies is most interesting and has been well described by Kocher,[10] they do not concern us at this time because in the *infant they are few in number, rudimentary, and functionless.* At this early time of life the cerebrospinal fluid passes directly into the cranial sinuses, chiefly the superior longitudinal. This fact is beyond question. The impelling factors determining this flow are the following:

1. The cerebrospinal fluid is a secretion from the choroid plexuses of the arterial system.

2. The pressure in the arteries is always higher than in the sinuses.

3. The pressure in the cerebrospinal fluid is below that in the arteries and always slightly above that in the sinuses. The flow therefore determined by differences of pressure is into the sinuses (Ballance [11]).

4. The specific gravity of the fluid (1005–1010) is below that in the blood (1059); the current determined by difference in the specific gravity of the two fluids is from that of the lesser to that of the greater. The fluid flows then into the blood stream.

5. The control of the passage of fluid into the sinuses is exercised at this early period of life by the open spaces between the cranial bones at the fontanelles, which are closed by an elastic, flexible membrane, whose rhythmic expansions and contractions vary with vascular, respiratory, and gravity pressures. They cease to functionate when the Pacchionian bodies begin to work.

6. Control over all these separate factors is exercised by the vasomotor system, so that the result of their combined function is to produce a constant intracranial tension. Slight variations, even, from this state are registered at once by

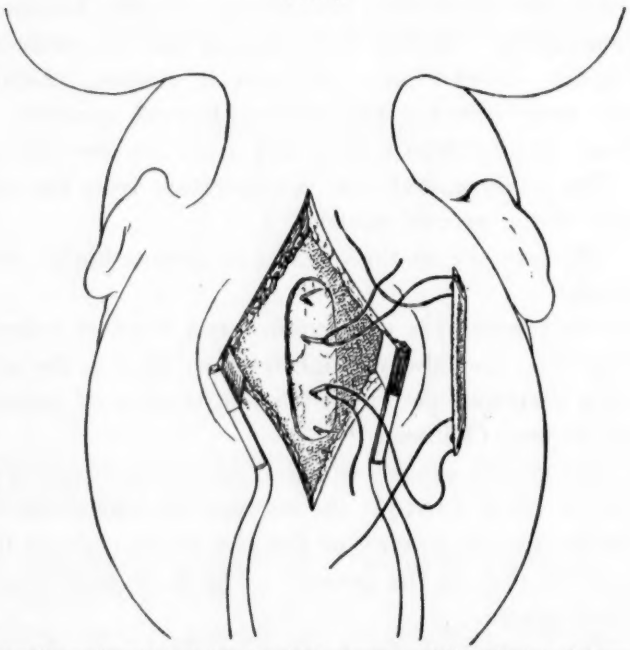
subjective disturbances, and greater variations later by both subjective and objective symptoms and signs.

B. CONGENITAL INTERNAL HYDROCEPHALUS.

Etiology.—The disease comes on early, at or soon after birth, usually before the third month.

First, let us consider the condition that is found at autopsy.

FIG. 4.



The needles are inserted, one into the cisterna magna and the other into the longitudinal sinus. If the occipital sinus were large enough it should be selected, if not the torcular; the longitudinal sinus, rarely.

The cranium is enlarged, even to immense proportions. The fontanelles are widely expanded, and other spaces, not usually open, are present, as a separation of the various sutures so that the individual bones of the cranium may have very little connection with each other. The head seems like a great bag of water. The ventricular cavities throughout the brain are dilated, as are their normally small connecting foramina or channels. Those openings which lead

into the basilar subarachnoid space,—the cisterna magna,—especially the foramen of Magendie, are widely open. *This space then becomes a component part of the great ventricular cavity.* The cortical parts of the brain are flattened out and pressed against the interior of the skull. The brain stem is not usually crowded into the foramen magnum.

Nothing abnormal may be found but this great collection of fluid. The condition is then called idiopathic, which really means that we do not know why it originates. At times a notable thickening is found in the ependyma covering the choroid plexuses. This has been interpreted by some as the *cause* of the collection of fluid from excessive secretion. But others assert with as much or more reason that this thickening is a *result* of such excessive secretion. The cause of the hydrocephalus may be due to an obstruction at the sinuses, as Cushing [12] claims, that prevents the fluid from flowing into the longitudinal sinus. That this is the chief causative factor is probable, but no direct proof is available to validate the statement, excepting this, that in the normal state large quantities of fluid may be caused to pass freely into the sinus without marked disturbance of the intracranial balance.

Various theories have been advanced indicating a prenatal meningitis. In syphilis, this has been proved, but there is no evidence to show that meningitis is the cause in the other cases of congenital hydrocephalus. No trace of such inflammation is found at the postmortem.

Whether the hydrocephalus is the result of excessive secretion or of deficient elimination or both, the fact remains that there is an abnormal amount of fluid within the ventricular cavities of the brain, and that this excess of fluid produces a definite condition and series of symptoms that will result in the death of the infant, unless relief be afforded by art or very rarely by spontaneous cure.

Symptoms.—The infant's head is distended to abnormal proportions by the excess of intracranial fluid. This fluid may be under great pressure. In one of my cases it rose to a

vertical height of 75 cm. in the manometer. This pressure, beside deforming the head, produces other symptoms, as displacement of the eyes with staring, strabismus, nystagmus, loss of accommodation, and even blindness. The scalp is thin, veins dilated, face shrunken. The head is so large that the child cannot lift or turn it. There is general emaciation even after the best regulated diet. The arms are flexed and the hands clinched. There may be contractures, but seldom paralyses. The child is very restless and cries continuously in a peculiar purposeless tone (Chapin and Pisek[13]).

If the intracranial pressure is not relieved, death usually ends the struggle. Hydrocephalus may become stationary, but most cases die during the first year, few live beyond the age of three, and very few to adult age.

Differential Diagnosis.—Rickets is the chief disease. But the square head with the other symptoms of rickets should make the distinction easy. However, both diseases may exist in the same individual. If a tumor is present, its diagnosis is very difficult and may be impossible.

Prognosis.—Distinctly bad.

Treatment.—"Medical treatment is of little avail" (Chapin and Pisek). The treatment must be surgical, but thus far this has been almost hopeless.

Part III.

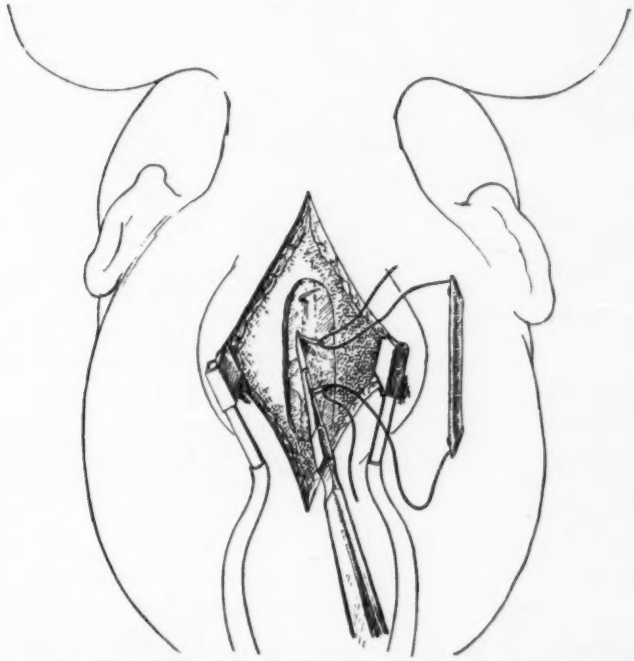
A. Summary of the various methods suggested and used in the treatment of hydrocephalus, with the names of the originators and a criticism of the operation.

1. *Intermittent Drainage.*—(*a*) Of the lateral ventricle. Ventricular puncture. It is stated (Bryant and Buck[7]) that Hippocrates tapped the ventricles for hydrocephalus. Stevens,[6] in 1745, suggested trephining in the case of Dean Swift. From this time to the present, ventricular puncture has been used by many surgeons for the treatment of hydrocephalus and also condemned by as many more.

Langenbeck,[6] in 1850, drained the anterior horn of the lateral ventricle by passing a trocar through the orbit.

In 1888, Keen[7] laid down the rules for ventricular puncture from the side. His point is 1½ inches behind and the same distance above the level of the external auditory meatus. Keen also noted that the ventricle could be entered

FIG. 5.



A narrow knife is passed along the shank of the needle to cut a very short vertical incision into the cisterna magna (also, later into the sinus).

from in front by taking a point ½ to ¾ of an inch at either side of the mid-line and one-third of the distance from the glabella to the superior Rolandic point. The bone must be trephined first in either procedure.

Ewart and Dickenson,[6] in 1891, varied puncture of the ventricle by forcing sterilized air in to take the place of the fluid.

For a detailed list of the operators and cases following these consult Kausch.[2] He states that he has collected from

among the numerous cases reported only six cases cured and two improved. These cases are so few that they might have just as well been the result of "spontaneous cure" as due to the ventricular puncture. The objections to this operation are: infection, which may result in connection with the first attempt or only after many punctures have been performed; sudden death from too free removal of the fluid or later death from a "cerebral disturbance" due to the same cause; return of fluid and death from the original disease. The operation is only used at present as a palliative measure for the first few weeks of a very young patient or as preparatory to more radical measures. Not more than 25 to 75 c.c. of fluid should be removed at any one sitting. This should not be repeated more than twice in one week, or once in two weeks.

(*b*) Of the spinal canal, *i.e.*, lumbar puncture.

Puncture of the spinal canal for hydrocephalus was first performed by Quincke [14] in 1890, but the spinal canal had been previously entered by Corning [15] in 1885 for the introduction of drugs and by Wynter [16] in 1889 for drainage of acute meningitis. However, owing to the very clear and complete description of this operation by Quincke, it has gone by his name ever since. Many operators have subjected numerous cases to this method of treatment with very little success. Archibald [7] says that "lumbar puncture is not of any permanent benefit."

The writer found almost no favorable results attributed to lumbar puncture except by Bókay [5] in 1910. His results in the treatment of nine cases of congenital internal hydrocephalus are so exceptional that the following brief summary of them is appended:

The average age at the beginning of Bókay's treatment was $6\ ^{2}/_{9}$ months. The youngest infant was 3, the oldest 9 months. The time of treatment varied from 4 months in the shortest case with a "perfect cure" to 4½ years in the longest case with the same result; and for the same length of time in another case with practically "no improvement." The average duration of treatment was 25 months.

The average number of punctures was 17, varying from 9 to 32 in the shortest and longest cases.

The smallest total quantity of fluid drawn was 205 c.c., the largest, 889 c.c.; the average for the 9 cases was 487. He claims the following results:

Case 1: Complete cure, with moderate hydrocephalus.
Case 2: Satisfactory improvement.
Case 3: Cured.
Case 4: Complete cure, normal head.
Case 5: Complete cure, hydrocephalus disappeared.
Case 6: Improved.
Case 7: Complete cure, hydrocephalus not disappeared.
Case 8: Marked improvement, moderate hydrocephalus.
Case 9: Scarcely any real improvement.

He states that in the 10 years from 1899 to 1908 there were 183,044 admissions to the Children's Hospital, among which were 334 cases of hydrocephalus. The first three years of life furnished the greatest number of cases, all varieties of hydrocephalus included. For our purpose, his paper is incomplete because we do not know to what method of treatment the other 325 cases were submitted. With a record of only nine cases out of this number, it suggests that he was very careful in the selection of the cases for lumbar puncture.

His results substantiate one contention of mine, viz., that *no matter what form of treatment is pursued, it must extend over a long period of time, i.e., until the Pacchionian bodies reach their development and begin to functionate.*

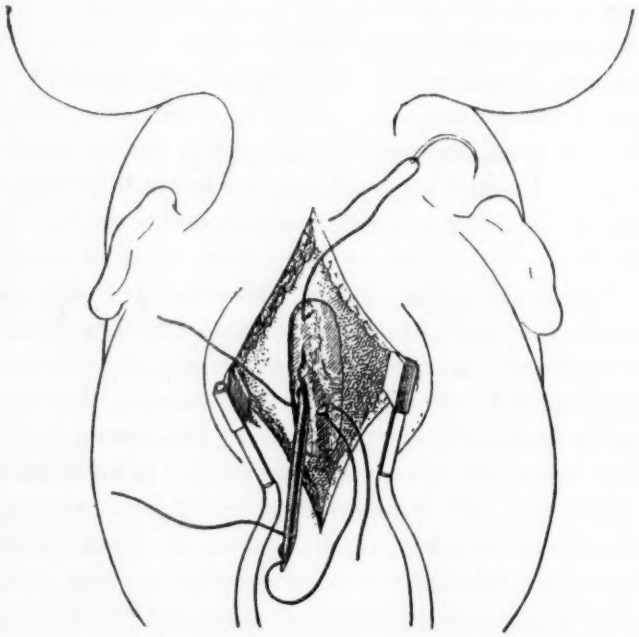
The success of lumbar puncture depends upon a free communication between the cranial and spinal subdural (subarachnoid) spaces. If the foramen of Magendie or the foramen magnum is blocked by an inflammatory exudate, lumbar puncture is clearly futile and death often follows from a "corking up of the foramen magnum by the brain stem."

(*c*) Puncture of the corpus callosum. Anton and V. Bramann,[2] in 1908, opened the skull near the mid-line, punctured the corpus callosum, then closed up the external

wound. It is evident that this method is not applicable to the treatment of this form of hydrocephalus that we are considering, inasmuch as it merely establishes a connection between different parts of the same hydrocephalic cavity.

2. *Continuous Drainage.—A.* Of the Lateral Ventricle. (*a*) To the surface.

FIG. 6.



The incision has been made into the cisterna magna, the needle and suture pulled through, and the tube shown ready to be passed into the incision.

Pollock [2] was probably the first to perform drainage of the lateral ventricle, in 1884. He used a drainage tube. He was followed by Zenner,[2] in 1886, by E. V. Bergmann in 1887 and by Keen [2] in 1888.

In the first cases a drainage tube was used. The fluid escaped so rapidly that death occurred very soon. This led Keen to use horsehair for drainage material. Silkworm-gut, catgut, rubber tissue were used by different surgeons with uniformly fatal results from too rapid escape of the fluid or

from speedy infection. Of all the cases reported, only two recovered and one was improved.

Le Cat (cited by Ricketts), October 23, 1744, punctured for hydrocephalus. Kausch[2] says the tube was permitted to remain in place. If this is so, Le Cat was the first to drain the ventricle to the surface for any length of time. This method is so uniformly fatal that it is no longer used.

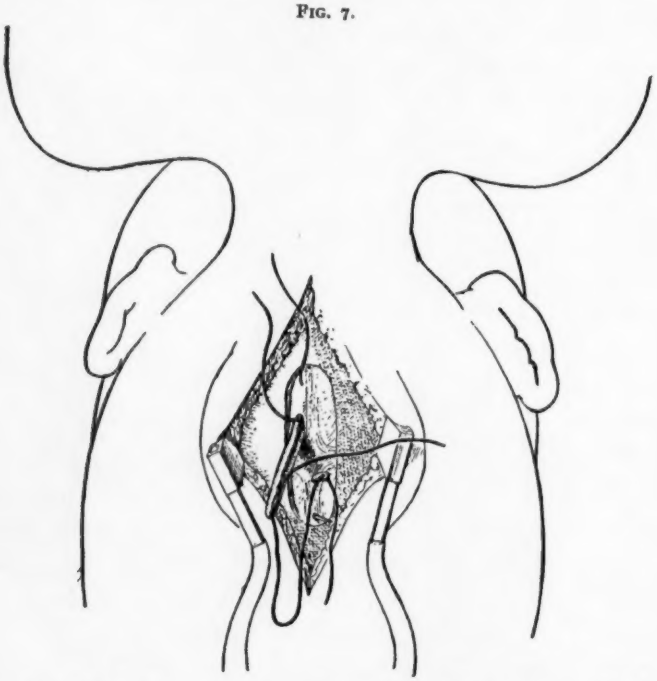
(*b*) Subcutaneous drainage of the lateral ventricle. According to Kausch, C. Wernicke, in 1881, was the first to suggest drainage of the lateral ventricle into the subcutaneous tissues. The idea upon which this was based was to prevent the almost certain infection which followed the open drainage. This method had a short life. It was soon found that while temporary benefit might follow its use, the original condition soon returned. This was due to the failure of the fluid to be absorbed from beneath the skin, fascia, or muscle on account of the exits for the fluid soon being closed up by plastic exudate and a regular cyst formed. This method has also been given up as unreliable, inefficient, and dangerous.

(*c*) Drainage into the subdural or subarachnoid space. (For this consideration these spaces are practically one.) While it is clearly evident that for the particular type of hydrocephalus we are studying this form of treatment is perfectly useless,inasmuch as the ventricular and subarachnoid spaces are parts of the general hydrocephalic cavity, yet in order to complete the subject the following will be noted. In 1893 V. Mikulicz first suggested this form of drainage, which he designated as permanent internal drainage of the lateral ventricle. This method is clearly indicated only in the acquired variety of hydrocephalus where there has been a stoppage to the flow of the fluid from one ventricle into another or into the subarachnoid space. Numerous are the operators and many the cases submitted by them to this form of procedure, with uniformly bad results. All sorts of drainage material has been used, as hair, catgut, silkworm-gut, tubes of rubber, glass, copper, silver, and gold. Kausch

records only one case that lived as long as seven months and one other that lived for six weeks.

However, E. Wyllis Andrews,[17] in 1911, reports a case in which he operated for acquired internal hydrocephalus by establishing a communication between the lateral ventricle and the subdural space by means of a glass tube. While there have been many modifications in the technic, the results have been

FIG. 7.



The tube has been passed into the cisterna magna and the suture is ready to be tied.

uniformly disappointing. The causes of death have been too rapid escape of fluid, infection, return of original condition, marasmus.

(*d*) Ventriculoperitoneal drainage. In 1905, Kausch[2] performed this operation by uniting the lateral ventricle with the peritoneal cavity by means of a small rubber tube, placed subcutaneously. Death followed in 17 hours from too rapid escape of the fluid. Autopsy showed that the entrance into

the aqueduct of Sylvius was completely closed. The cerebral cortex was only 2 to 3 mm. thick. In the abdomen the drainage tube was found clear, and fluid slowly escaping from it. Kausch thinks that this method of drainage may be easily controlled so that such sudden emptying of the ventricles may not occur. He says that the peritoneum freely absorbed the large quantity of fluid emptied into it.

In 1910, Hartwell [18] accomplished the same object by uniting the lateral ventricle to the peritoneal cavity by means of a silver wire, provided with bulbous ends, that was passed subcutaneously from the mastoid region down the side of the neck, over the clavicle, down the midclavicular line, and into the peritoneal cavity just beneath and outside of the right border of the liver. In this case the result was favorable so far as establishing drainage was concerned. The first wire was too heavy and the movements of the neck finally broke it. However it was apparent that a definite cicatricial tube had formed around the wire through which the fluid flowed. The first wire was replaced by a smaller one, and drainage kept up intermittently until the child's death some two years later. Autopsy showed the cause of death to have been due to a tumor in the aqueduct.

Hartwell says that the idea was not original with him, as he got it from Dr. Robert Abbe, in part at least. This method is worthy of further trial. There are so few cases recorded that no conclusions can be formed at this time as to its real value.

If one were to attempt this operation, I would suggest that, instead of tube drainage or the silver wire used by Hartwell, the silver wire cable devised by Lilienthal [19] be used. This is sufficiently strong and very flexible, and may be obtained in small gauge.

(*e*) Drainage of the lateral ventricle into the temporal vein. In 1908, Bier [3] followed Gärtner's suggestion (see under Payr's operation, below), and transplanted a portion of the temporal vein into the lateral ventricle through a trephine opening in the side of the skull. The patient died

five days later. The autopsy showed that the transplanted vein was necrosed and thrombosed. Later, Schmieden [3] performed the same operation, but the result is not stated.

Kanavel,[20] in June, 1909, attempted a similar operation. He utilized "a large vein running up the side of the child's head." The vein was freed and thrust through an opening into the dura and sutured in place. The child did well for ten days, when the vein became occluded and the fluid reappeared. The child died a week later.

Carl Beck [21] states that four years before Payr published his cases he had tried the same method described by Kanavel. The patient died. At a later time he resected the external jugular vein and transplanted it. The result was gratifying for some time, but after six months there was the same symptom complex as before.

Regarding the plan to drain the ventricle into the veins of the neck, further work along this line may give more encouraging results than the few attempts in the past have shown. If the plan is feasible and desirable, I would suggest that the communication be made between the occipital vein and the cisterna magna for reasons of avoiding the cortex of the hemisphere and its attending traumatism. I have not even worked the technic out on the cadaver, and merely throw out the suggestion in passing.

(*f*) Drainage of the lateral ventricle into the superior longitudinal sinus. In 1895, Gärtner [2] asked if it were not possible to establish a communication between the hydrocephalic cavity and the lymphatic or the venous system through a cranial sinus or by means of a vein of the head.

Payr,[3] in 1907 (December 19), was the first to attempt to put Gärtner's suggestion into practice. He used a portion of the long saphenous vein to establish a communication between the cavity of the lateral ventricle and the superior longitudinal sinus. He performed this operation twice on one patient that lived for three months after the second operation and for five months after the first. His second

case, third operation, died two hours after the operation. Further consideration of this method will be deferred until later.

B. Continuous Drainage of the Spinal Canal. (*a*) To the surface. In 1873, Paget [3] resected the third and fourth cervical arches and drained "without result."

All forms of continuous drainage to the surface by means of tubes, laminectomy, etc., have been abandoned, as previously stated, on account of the escape of fluid being too rapid and infection sure to follow.

(*b*) Into the retroperitoneal tissues. Nicoll [2] in 1899 suggested draining the fluid from the spinal canal into the retroperitoneal tissue, by the resection of one or both transverse processes of the second lumbar vertebra, blunt separation of the muscles, and drainage by means of a decalcified bone tube, or by using temporarily a glass or rubber tube. This plan has nothing to commend it over numerous other plans. The objection is not so much to the technical difficulties as to the fact that fluid in abnormal situations soon develops a cyst and absorption ceases.

(*c*) Drainage into the peritoneal cavity. Ferguson [2] in 1898 published the first case of this kind. He resected a portion of the fifth lumbar arch, drilled a small hole through the body of the vertebra into the peritoneal cavity, and established a connection between this space and the spinal canal by means of a loop of silver wire. His first case died at once, apparently from a too sudden loss of spinal fluid. His second case was improved, but died three months later of bronchopneumonia.

Damas [2] later suggested the resection of two sacral arches and connecting the spinal canal with the pouch of Douglas. He had not tried it on the living.

In 1908, Cushing [7] established permanent drainage between these two spaces by adding a laparotomy to Ferguson's technic and using a silver cannula consisting of two portions, similar to an elongated Murphy button. He reported a considerable measure of success. Fowler [22] in 1909 reported three cases

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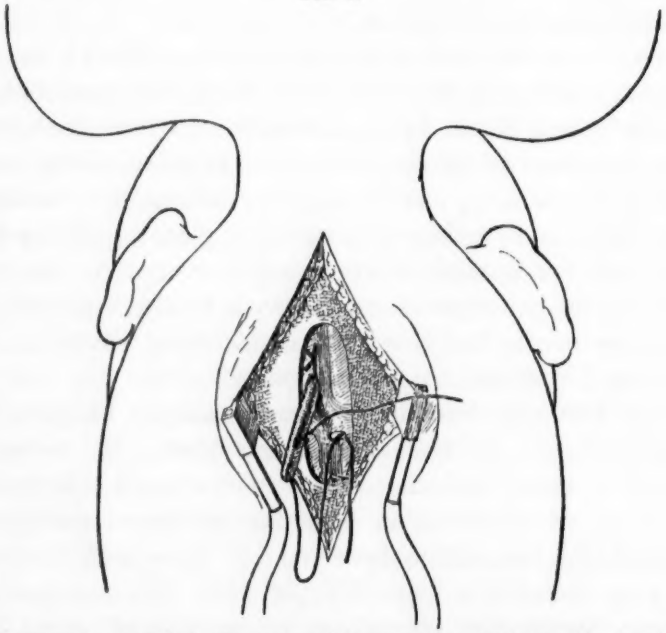
treated by Ferguson's and Cushing's technic. His first case seemed to have the disease arrested after two months. His second case died after a decompression operation following the spinal drainage. His third case died on the table after breaking up adhesions about the cerebellum as he was about to close up the soft parts.

(*d*) Hydrocephalus complicated by spina bifida, the former treated through operative interference with the latter.

FIG. 8.



The suture has been tied. The design of this suture is not only to guide the tube into position, but also to fasten it there, and further to hold together the two membranes, the dura and arachnoid, which are found at this point.

Kausch [2] gives a summary of these cases which have been operated upon. The prognosis is even worse than in hydrocephalus alone. The various measures used are directed primarily to the treatment of the spina bifida.

(*e*) Drainage of the subarachnoid space, "fourth ventricle." Ballance [23] in 1891 was undoubtedly the first to practise drainage of the cerebellar fossa. Parkin, [24] Ord and Waterhouse [25] all performed the same operation of trephining

laterally over the cerebellar lobes and instituting drainage with difficulty if at all. All their cases were suffering from meningitis.

Roswell Park[6] in 1893 was the first to drain the cerebellar fossa for hydrocephalus. His technic and Parkin's are practically identical.

Glynn and Thomas[6] in 1895 trephined and opened the fourth ventricle with recovery of the patient.

All these attempts at draining this region were to the surface. If death did not result from too rapid escape of fluid it usually followed later from infection.

(*f*) Drainage of the cisterna magna into the cranial sinus. (Devised and performed by Haynes, Oct. 22, 1912.) Case recovered, improved steadily for a month, followed with return of symptoms due to probable closure of the opening into the occipital sinus. Case still living but slowly succumbing to marasmus. Second case died three days after the operation of connecting the cisterna magna with a parietal emissary vein from loss of cerebrospinal fluid through the incision, between the sutures.

(*g*) Other measures. Treatment by seton, injection of iodine, by galvanopuncture, compression of the head, and by drugs require only passing mention.

(*h*) Indirect treatment. Harold J. Stiles,[26] reasoning that hydrocephalus is due to an over-secretion of the cerebrospinal fluid, has ligated both internal carotids, at different sittings. He reports favorable results (1911).

Ransohoff[26] reported two cases of carotid ligation with "most gratifying results." Frazier[26] also stated that a recent case of his seemed to be benefited by the operation. These cases are too recent to show final results. Later reports will be awaited with interest.

B. CRANIAL VERSUS SPINAL OPERATIONS.

In selecting an operation for the treatment of hydrocephalus, we naturally have to decide at first between the spinal and the cranial routes. Any spinal operation

presupposes that the communication between the cranial and spinal subarachnoid (subdural) spaces is free. If there is a block at any point in the intracranial passages, at the foramen of Magendie, at the foramen magnum, or in the spinal canal itself, a spinal operation is futile for therapeutic purposes and also may be fatal from "corking up of the foramen magnum by the brain stem."

As to the spinal operations themselves, this may be said: that they are limited in their application; that continuous drainage to the surface is contraindicated, because death will occur early from too rapid loss of fluid or a little later from infection; that regarding lumbar puncture, with the single exceptions of Bókay, it is universally admitted to be only a palliative measure and has given no permanent curative results.

Regarding drainage into the subcutaneous, subfascial, or submuscular tissue, it is found that, while the tissue may for a short time absorb a considerable amount of fluid and the duration of this action may be prolonged by massage and efforts at increasing the hyperæmia of the parts, still in a comparatively short time the space becomes the seat of plastic lymph exudate, the avenues of escape are closed, the absorption of fluid ceases, and a cyst is formed. This method of drainage, therefore, soon becomes inoperable.

We have left, then, only the spinal peritoneal method of Ferguson and Cushing. Their plan of treatment is clearly limited to a very few cases. Requiring a laparotomy and a laminectomy as preliminary to the actual drainage technic, it is a procedure of great severity that can be borne only by a comparatively strong child, but these sufferers from hydrocephalus are not sturdy—far from it; and if there is an easier way to secure the desired result it should be used. Aside from the technical drawbacks, this plan does not yield any better results than many others. The child dies from sudden evacuation of the fluid or from a return of the original condition due to closure of the drainage tract.

The indirect method of ligation of the carotids advocated

by Stiles is too recent to be judged at this time. His claims are worthy of very careful investigation, and time alone will prove the value of this treatment. Whether his contention is true or not, that the disease is due to an over-production of fluid, it has no bearing on the case so long as he gets cures by cutting off the excess of blood to the brain. That this may result in other less desirable effects, as arresting the development of the brain itself, has not been determined at present.

We come, then, to a consideration of the treatment of hydrocephalus by direct attack upon the disease itself in the cranium. Of the methods proposed we may dismiss from our consideration all but the following: (1) internal drainage; (2) ventriculoperitoneal drainage; (3) ventriculosinus drainage; (4) cisterna magna and sinus drainage; (5) cisterna magna and peritoneal drainage, a suggestion.

1. In reference to internal or ventriculo-arachnoid drainage, as this is clearly limited to the acquired variety of hydrocephalus its consideration is beside our present purpose. We may say this, that it has been successful in a few appropriate cases.

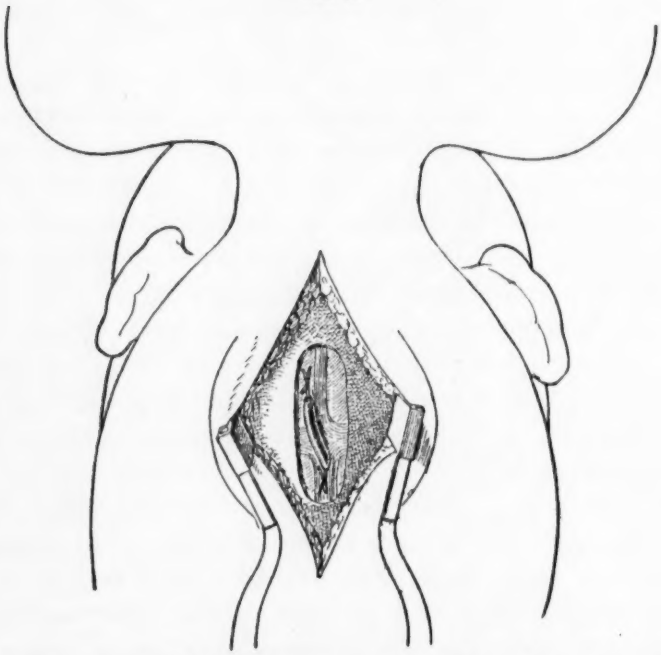
2. Drainage of the ventricles into the peritoneal cavity has to the present time given the greatest promise of eventually proving of real value. The use of a fine silver wire, by Hartwell, or the silver wire cable of Lilienthal, overcomes many of the disastrous difficulties in any operation upon this class of cases.

Plans 3 and 4 will be taken last.

5. Cisterna magna and peritoneal drainage: In connection with drainage of the ventricles into the peritoneal cavity, these thoughts came to me. The chief danger in any of these hydrocephalic operations is death from sudden loss of fluid. Now if this plan of treatment can be carried out without such attending risk, the results should be correspondingly improved, therefore, I am led to make the suggestion that, if there is no block within the intracranial ventricles or their channels of communication, the cisterna magna should be

exposed by a trephine opening ⅜ of an inch in diameter, midway between the margin of the foramen magnum and the occipital protuberance, in the middle line, that Lilienthal's silver wire cable of fine size be passed by the writer's dural needle through the membranes so as to traverse the cistern, that its short end be twisted around the long part of the cable,

FIG. 9.



The operation of inserting the tube is shown completed. The bone detritus may be packed into the gap and the skin tightly sutured.

which then is passed beneath the skin into the peritoneum over the surface of the liver on the right side. It would seem that this would accomplish relief from two main difficulties: first, prevent the sudden initial escape of the fluid and death; second, so gradually conduct the fluid away from the head that the intracranial pressure would gradually subside, a return to normal be permitted, and that it would functionate until the Pacchionian bodies were developed and took up the work permanently.

4. In reference to Payr's operation: It is based upon the same reasons and facts as that of the writer. These arguments will be left to be considered after the operations themselves have been criticised.

Payr's Operation.—An omega-shaped flap of skin and bone is formed crossing the middle line near the bregma. Its base, 2 to 3 cm. wide, is placed a finger's breadth at one side of the mid-line. This osteoplastic flap is reflected, and a U-shaped flap of dura turned back, exposing the superior margin of the hemisphere. A long, small, graduated needle is used to determine the thickness of the cortex, and Payr says it is advisable to allow a portion of the cerebrospinal fluid to escape so as to relieve the stasis in the veins of the pia and prevent any considerable hemorrhage from the dural flap or the cortical surface. During the work upon the head, an assistant excises a portion of the long saphenous vein about twice the measured distance to be traversed, as vessels shrink fully fifty per cent. when removed from the body. This portion of vein should be wrapped in gauze moistened with physiological salt solution, and kept at a temperature of 37° C. over a water bath. The distal and peripheral ends of the vein should be marked.

An aluminum trocar, 2 to 4 mm. in diameter, is passed into the ventricle, some more fluid is allowed to escape. With a bayonet-shaped probe the distal end of the vein is passed through the trocar into the ventricle and the trocar removed. The vein should project slightly into the ventricle. The vein is held in place by a fine suture through the pia-arachnoid and itself. Too sudden escape of cerebrospinal fluid must be guarded against or severe collapse, arrest of respirations, also inspiration of air into the ventricle may occur. Often immediate death follows sudden escape of the fluid.

The longitudinal sinus must be exposed for 2 to 3 cm. in order to accomplish provisional hæmostasis. The presence of lacunæ laterales must be noted and avoided. Hemorrhage is prevented by Payr's special clamp, by his inflatable rubber bulbs, or by elastic ligatures around the sinus.

A narrow incision is made into the sinus, into which the

free end of the vein, a cuff having been turned back so as to bring the intima outside, is inserted and fastened in place by fine silk sutures. The flap of dura is accurately sutured in place and the osteoplastic skin flap similarly treated.

Objections mentioned by Payr: That it may not be possible to secure a portion of vein of sufficient length or free from pathological changes. That in numerous cases of hydrocephalus the superior longitudinal sinus is wanting or is obliterated by inflammation or thrombosis. That it may be impossible to complete the operation on account of severe hemorrhage. That the anastomosing vein may be compressed by faulty suturing, or it may be implanted in the wrong direction. That the vein may necrose as a result of lack of nutrition, or from mechanical, thermal, or chemical disturbances. That the sinus may become thrombosed, or a clot form in the vein. That the anastomosing vein may be forced out of the ventricle or its lumen closed by prolapsed brain tissue. That secondary infection may occur. A contra-indication for drainage into the sinus is any inflammatory process in the ventricular cavity, as cerebrospinal meningitis, tubercular meningitis, and he names several other conditions. A biochemical test must be made of the cerebrospinal fluid drawn by ventricular or lumbar puncture. Finally, he says this technic should not be attempted in hopeless cases.

Part IV.

A. A summary of the facts upon which drainage of the hydrocephalic cavity into the cranial sinuses is based.

1. Congenital, internal hydrocephalus appears at or soon after birth.

2. The condition is due to an excess of fluid in the skull.

3. Normally the cerebrospinal fluid is always at a slightly greater tension than the blood in the venous sinuses.

4. In hydrocephalus this difference in tension may be more than ten times that of the normal, as my case demonstrated.

5. The current in the cerebrospinal fluid determined by the normal difference of pressure into the sinuses.

6. One of the chief reasons for the development of hydrocephalus is the failure of the fluid to take its normal course due to some block at the entrance into the sinus.

7. The current determined by osmosis is from the cerebrospinal fluid to the venous blood, because the specific gravity of the former is so much lower than that of the latter.

8. There is no appreciable passage of the cerebrospinal fluid into the lymphatic system in the normal nor in the abnormal state, as the fluid is not lymph but a true secretion.

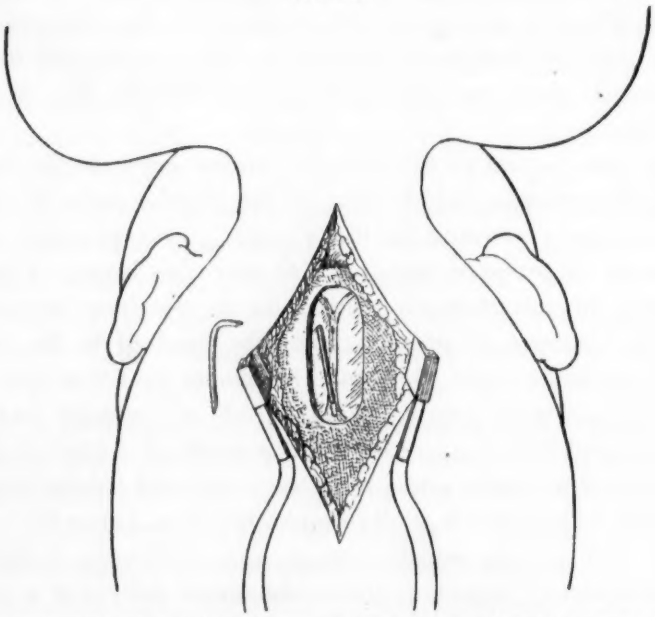
9. The current of blood in the sinuses is toward the heart, with an equalizing mechanism at the jugular bulb to maintain an even pressure in the sinuses. This pressure may, however, at times be negative. It may also be raised by an increase of intrathoracic tension, as in coughing, straining, also by changes of position from the head-up to the head-down positions. *But one should remember that there are two columns of fluid passing to the head, the arterial and the venous,* and that pressure in one as a result of a general cause must exert a similar pressure in the other, and further that as the arterial pressure is at all times higher than that in the veins, there will always remain this normal difference under all circumstances. Again, as the cerebrospinal fluid is at a pressure between that in the arteries and veins, an increase of pressure in those systems will only result in producing a corresponding rise in the cerebrospinal pressure. If anything tends to change the relation between the arterial and venous systems in the head, it would seem that inasmuch as there is a trap-like formation in the terminal sinuses and no such obstructive mechanism in the arteries, the arterial system would show a slightly relative, higher degree of pressure than the sinuses.

Further, while the foregoing applies to the normal state in the hydrocephalic child the pressure in the fluid is many times higher than in the sinuses, and there can be no tendency

for the blood to escape from the sinuses into the hydrocephalic cavity. Fluid cannot flow up hill nor from a vessel of lesser into one of greater pressure.

10. Any current flowing through a tube of larger diameter will act by suction to draw into its circulation the fluid from an adjacent space communicating with it by a tube of smaller dimension, no matter whether the pressure in the adjacent

FIG. 10.



A silver cannula is used in this instance. Its dimensions are, internal diameter 1.5 mm., length of long arm about an inch and of the short arm, one-quarter inch. The ends are ground obliquely. In the diagram the occipital sinus is shown as the site of drainage; the torcular may be used if this is too small or is wanting.

space be at the same or a higher or a lower degree. This fact is demonstrated by the common injecting pump.

11. One concrete fact proves more than pages of argument. Payr states that in his cases autopsy showed there was not even a drop of blood in the ventricles. This, too, in spite of the fact that in one hemisphere there was a ragged hole 3×1 cm. Neither was there any blood found in the case where from loss of fluid the cortex had collapsed during the operation.

Further, in the personal case reported where I believe drainage was established into the occipital sinus there were no signs of internal bleeding. Also, in my case where a silver tube was used to connect the cisterna magna with the longitudinal sinus by means of the parietal emissary vein, there was no blood found in the former space, as shown at the post-mortem examination.

12. The cerebrospinal fluid is isotonic with the blood; blood escaping into this fluid does not coagulate (Archibald).

13. There can be no doubt but that the thin sheet clot of small pial hemorrhages is ordinarily absorbed without causing symptoms and leaving trace (Archibald).

14. Even if a small amount of blood should escape into the cisterna magna, Archibald says, "With blood at the base of the brain there will be more or less disturbance of consciousness, from stupor to coma, with headache, usually severe, and with perhaps some slowing of the pulse and some rise in blood-pressure. The symptoms are not alarming, and it is easily seen that they will disappear without interference." If this is the case in a normal individual, how much quicker would the blood disappear in a hydrocephalic case in which the cerebrospinal fluid was at a tension greater than normal and in which there was a channel through which the bloody fluid might escape into the sinuses.

15. In the infant the fluid passes directly into the longitudinal sinus. Under experimental investigations it is found that very large quantities of artificial cerebrospinal fluid will leave the skull by way of the sinuses.

16. In hydrocephalus the cerebrospinal fluid is normal to all biochemical examinations.

17. The theory that the excess is due to an over-secretion of fluid is hardly tenable and not demonstrated, even by the results of carotid ligation. The block is at the entrance to the sinus. What that block consists in no one knows. That there is some passage of the fluid into the sinuses in hydrocephalus must be admitted. The result then of carotid ligation is merely to reduce the output of fluid so far below the

normal, that the smaller quantity of fluid secreted after this operation is taken care of by the diminished excretion at the sinus.

18. There usually is no interference with the passage of fluid from the ventricles into the cisterna magna in congenital hydrocephalus. As a matter of fact the passages are more widely open than normal, the cisterna magna is then a true part of the hydrocephalic cavity, and drainage from this region will be as effective as from the ventricular portion.

19. The simplicity of drainage of the cisterna magna into the sinus, when contrasted with any other form of ventricular drainage, is apparent from a study of the operative technic in the several operations.

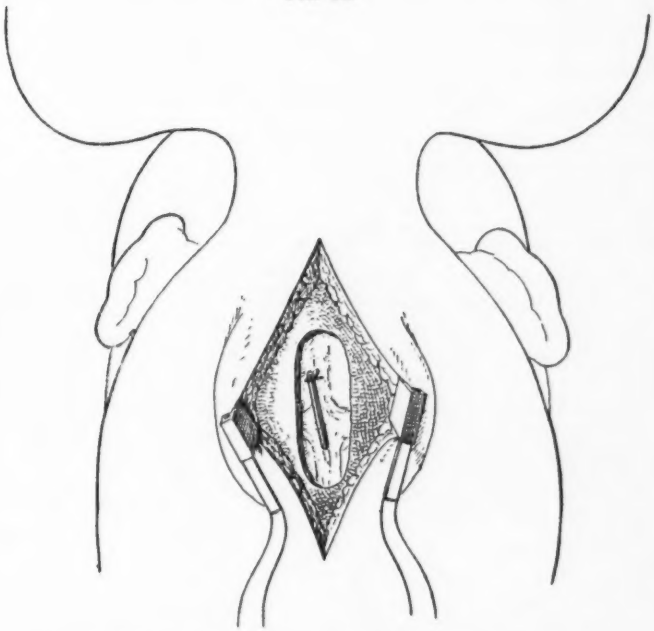
20. Cisterna magna-sinus drainage being simpler than ventricular-sinus drainage and without the drawbacks of the latter operation, is to be preferred when this type of drainage is deemed advisable. The following difficulties and operative measures are not encountered: (*a*) The dissection for drainage use of a portion of a vein, and keeping it viable until used. There are numerous trifling incidents which might render the vein soon impermeable after the work had been completed. Many more risks attach to the technic of successful venous transplantation than do to the insertion of a tube, rubber or silver. (*b*) In the cisterna drainage the dura is not reflected at any point and the brain is not exposed. Exposure of the cortex is attended with some risk; however, this may be overcome, but collapse of the brain from loss of fluid is not only fatal to the success of Payr's operation, it is fatal to the patient. In cisterna drainage the loss of fluid is under the absolute control of the operator during the operation. In both operations, if it were necessary, physiological saline solution might be injected into the interior of the brain. (*c*) There is wounding of the cerebral cortex in Payr's drainage and the dangers of hemorrhage from such source. There is also danger of damage to the choroid plexuses from the tube used for ventricular puncture.

21. After a careful consideration of the operation of Payr, it is the writer's opinion that while it is right in principle it is

too severe and difficult in practice. The difficulties in the way of carrying out the steps of his technic are almost insurmountable with the preservation of a drainage scheme and with a living patient.

22. There is an automatic regulation of the flow of fluid into the sinus in Payr's and the writer's operation that must not be lost sight of. One of the chief causes of death, found

FIG. 11.



The operation is completed by placing a suture across the tube to hold it in position. The wound is closed as in the previous method.

after any operation either upon the spinal canal or cranium, is the too sudden and too free and continuous loss of cerebrospinal fluid. Now with cisterna-sinus drainage, starting with a considerable difference between the pressure within the hydrocephalic cavity and that in the sinus, as soon as they had become equalized the flow of fluid would automatically cease, the fall of pressure in the ventricles would be at least no lower than that in the sinus, and the fatal collapse of brain and patient, the so common final picture with too rapid escape of

fluid, would be lost. If the secretion increased the flow would also increase, if the secretion diminished the flow would also diminish from the cistern into the sinus. It would be absolutely automatic, in the ideal case.

23. Therefore, believing that the operation suggested is based on sound reasons, that its technic is neither too severe to the patient nor difficult for the operator, that it contains a germ of truth and a promise of success, it is offered to my fellow workers as a possible solution for the treatment of this uniformly fatal disease.

PART V.

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THE EFFECT OF THE REMOVAL OF THE HYPOPHYSIS IN THE DOG.*

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AND

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THE problem of the physiology and pathology of the hypophysis represents one of the curious instances in medical science of such contradictory observations, often additionally deflected by speculative fancy, that the answer to any given question concerning the function of the gland in health or disease is even yet not certainly established. The apparently simple proposition—is the organ essential to life?—has divided all workers into two almost evenly balanced groups: those who maintain that the gland is essential to life, and those who hold it to be non-essential.

A detailed review of the literature is here unnecessary, since the appearance of the excellent paper by Aschner (*Pfluger's Archiv.*, 1912, cxlvi, p. 1). Aschner reports extensive experiments made chiefly upon young dogs, discusses the various functions and supposed functions of the hypophysis, and gives a very complete bibliography, covering both the experimental and clinical literature of the subject. We wish in this paper to briefly discuss our own findings, and to leave aside for the present the consideration of results which we have not been able to corroborate.

The work on which this report is based began over a year ago, when the question of the essential character of the hypophysis was perhaps of more importance from the stand-point of experimental medicine than it is to-day. It is evidently a question of prime importance to the surgeon, for if it be really essential to life, the limit of safety in partial removal

* Read before the Philadelphia Academy of Surgery, December 2, 1912.

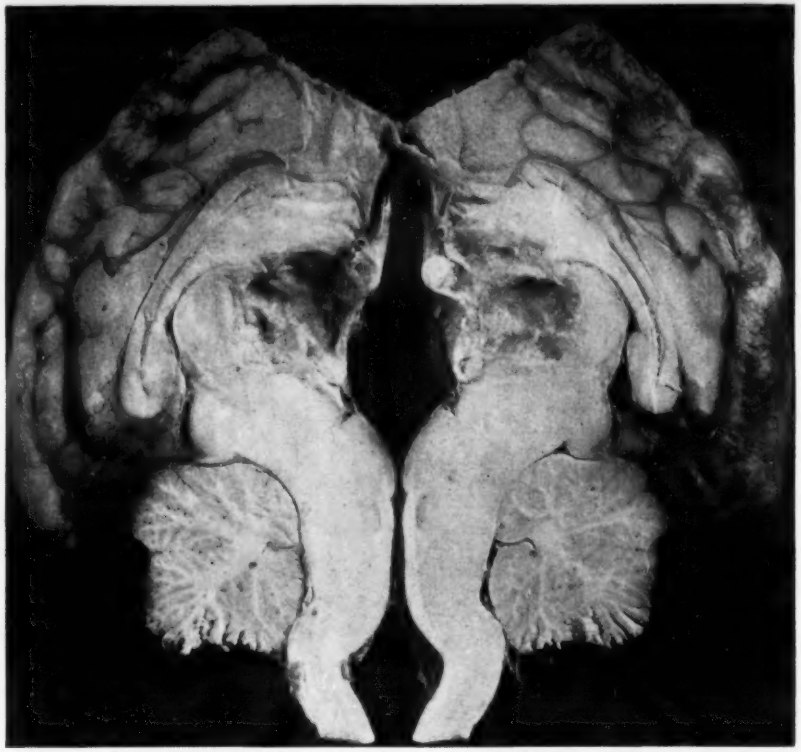
must be determined. The results in 22 dogs are as follows: 4 died after an average of three days of evident traumatic encephalitis; 1 died of acute lobar pneumonia after two days; 3 died after an average of 23 days of distemper pneumonia; 4 died after an average of 15 days of basal meningitis; 1 died after 38 days, showing at necropsy a thrombosis affecting the hemisphere opposite the field of operation, with a large abscess of the base; 2 died after an average of ten and a half days, the cause of death being uncertain; 2 met accidental deaths after an average of 23½ days; 5 lived for months. None of these dogs showed any immediate symptoms peculiar to the operation, no peculiar gait, nor position, no tremors, nor any other clinical symptom; recovery was prompt and without complications.

The method of approach is through an incision about 2 inches in length, perpendicularly over the centre of the zygoma —the zygoma forming, as it were, a base line with the two-inch incision extending perpendicularly to such a base line. The zygomatic arch is removed, the coronoid process of the mandible resected, and the base of the skull approached in a direct line. The skull is trephined and the hole somewhat enlarged, and after opening the dura, the brain is carefully elevated by a suitable retractor. The hypophysis is then removed by a special loop forceps (Fig. 1) which enables the operator to grasp the gland and generally remove it in two pieces, the anterior lobe in one piece and the posterior lobe separately. The wound is closed without drainage. With a strong light the field of operation is ample and no difficulty is encountered. This approach, which has been used before, was chosen because the Paulesco-Cushing incision with its extensive removal of the skull seems unnecessary and in our opinion exposes too large an area of the brain to the compressive action of the large masseter muscles. In several instances the operation has failed because of an atypical course of a large branch of the pterygopalatine artery. This branch, ordinarily not in the field of operation, has now and

FIG. 1.

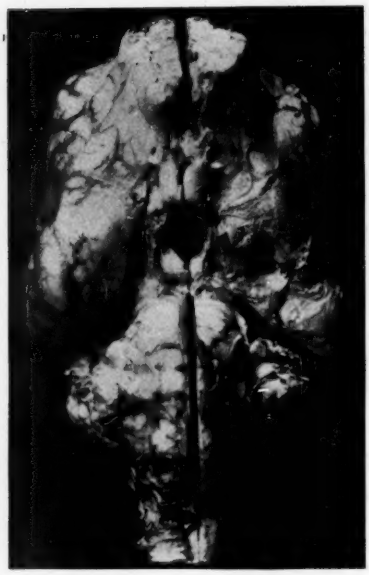
Brain retractor, from beneath, showing rounded edges. Loop forceps, for grasping the hypophysis.

FIG. 2.



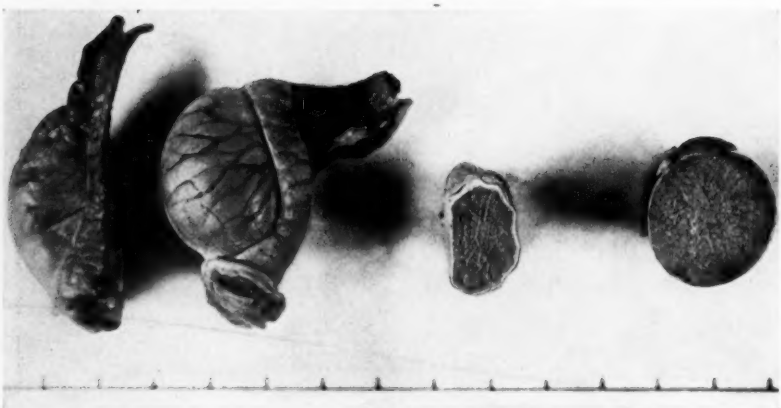
Dog No. 1. Lived 38 days. Shows what must be complete removal of all hypophyseal tissue by the extensive area of softening.

FIG. 3.



Dog No. 1. Area of softening.

FIG. 4.



Dog 19. Atrophy of testicles. On the right, testicle removed at time of hypophysectomy. On the left, companion organ, fifteen days later.

FIG. 5.

Dog No. 15. Eight months after operation.

FIG. 6.

Dog No. 13. Eight months after operation.

then been unexpectedly cut, with a resulting hemorrhage very difficult of control.

The first point which we sought to determine is whether the entire gland can be removed by this or any other method. Two points must here be recognized: Are we justified in speaking of a complete physiological extirpation when either macroscopically or microscopically some portion of the gland can be recognized after the operation? The anatomy of the gland in the dog is such that it is probably impossible to completely remove all the cells of the pars intermedia. These cells extend for a considerable distance forward toward the chiasm and backward toward the corpora mammillaria. Such a condition makes total removal from a microscopical point of view impossible, but can the gland be physiologically removed? The point is perhaps well illustrated by the history of the work upon the relation of the complete removal of the pancreas to diabetes. It is doubtless impossible to remove completely every cell of the pancreas, and because of this fact the relation of the pancreas to diabetes was for a time in dispute, the explanation being offered that the diabetes was due to the nervous shock incident to the operation. Nevertheless there can be no doubt to-day that enough of the pancreas can be removed to ensure physiological results. It is the same with the parathyroids and with the thyroid, so that a limit of safety has been established by surgeons beyond which it is not safe to remove thyroid tissue. We believe that it is possible to remove the hypophysis physiologically, that is, to remove enough so that certain characteristic changes will follow. Dog No. 1 (Figs. 2 and 3) lived for 38 days, showing no peculiar symptoms until shortly before death, when symptoms of meningeal irritation developed. The autopsy showed an extensive area of softening in the infundibular region, which, as shown in the accompanying plates, must certainly have removed all hypophyseal tissue. Concerning the extent of removal of the hypophysis we have taken the following means of ascertaining whether we have been successful in completely removing it: At the autopsy of several animals which died early, and of all

those which lived for months, a block of tissue was removed which included the optic chiasm anteriorly and the corpora mammilaria posteriorly, with about 4 mm. of tissue each side of the medial sagittal plane. This block was mounted in paraffin and serial sections prepared. Careful examination of this material revealed that in only two dogs, dogs Nos. 11 and 22, can it be said that there is no evidence of either pars intermedia or pars anterior. The remnant of the gland found in dog No. 12 was functionally very active, if one may judge by the extensive colloid-like formation and the same appearance of the cells of the pars intermedia which one sees in the normal gland; this dog presents complete atrophy of the testicles.

In the work reported by Aschner with young animals he notes that, in his experience, no marked changes occur after the removal of the gland from the adult dog. The dogs in our series were all full grown. We have no means of judging their exact age except by the fact that they all possessed at the time of operation a complete second set of teeth; in fact, dogs Nos. 19, 20, and 22 were noted as old, their front teeth being worn down almost to the gums.

In this series the first change to be noted was an indetermined effect upon the pancreas. At the autopsy of the dogs in the latter part of the series, that is, in those dogs in which we regularly made note of the condition of the pancreas, it is recorded that the organ presented a striking red coloration, having at autopsy the appearance of the gland seen at the height of digestion. Ordinarily at autopsy the pancreas presents the usual picture of a pale, even whitish, organ, the lobules at the edge being rather hard to differentiate from the neighboring fat tissue. In these animals the pancreas was evidently much congested and yet the microscopical study of sections of these organs did not reveal any very marked changes. The changes seen were perhaps identical with those to be found in a pancreas at the height of digestion. The second change in point of time, which we have noted, has been the atrophy of the genital apparatus, particularly of the tes-

ticles. From dog No. 19, at the time of the operation (Fig. 4) upon the hypophysis, the left testicle was removed; 15 days later the dog choked to death in an endeavor to swallow a whole cold boiled potato. The autopsy showed that the remaining testicle had undergone a very marked atrophy, due microscopically to a complete loss of the spermatogenetic cells. Dog No. 20, likewise an old dog, showed the same condition of striking atrophy after three weeks. Dog No. 21, dying on the thirteenth day from an undetermined cause, shows no clusters of young spermatozoa in Sertoli cells nor spermatozoa free in the lumen. Spermatids of first and second order are present in moderate quantity. The epididymis is crowded with spermatozoa. Just how soon after the removal of the hypophysis this atrophy commences we are unable to state, but from the three cases cited it is evidently very early. The third change which we have noted has been the increase in weight. This change in our experience does not begin until some time after the operation. For example, Dog No. 15 (Fig. 5), operated on February 7, 1912, weighing about 17 kilos, showed no particular change until the middle of the following June; the dog then weighed 18 kilos. On October 4 the dog weighed 27 kilos. The same may be said of the other dogs in our series (Fig. 6), so that the question has arisen in our minds whether this tendency to obesity is due to a loss of the hypophysis or to a loss of some other function of the body which is controlled by the hypophysis.

The change in the pancreas has been a constant finding; the testicular atrophy apparently is quite constant. Dog No. 16 showed what seemed to be a decided atrophy on palpation some weeks after operation, but at autopsy 7 months after the testicles were normal; this dog showed quite a large rest of pars anterior and pars intermedia, but dog No. 12 showed an equally large rest, with complete atrophy of the testicles, and dog No. 22 showed no demonstrable gland substance, yet had normal testicles. The increase in weight is apparently constant if the dog lives long enough. Perhaps the most important question to-day in connection with the ductless glands is

the matter of their interaction; are we to consider the hypophysis, for instance, as a link in a chain, which link, if broken, breaks the chain, or as members of a family, where if one member drops out, he can never be replaced, but the other members of his family can take up his work to a greater or less extent?

In three of the dogs which we have autopsied after several months' time, the thyroid presented a change, the significance of which is hard to interpret. There is an evident increase in the amount of colloid with a flattening of the cells of the alveoli. In summing up our experience with these 22 cases, it is evident that the hypophysis is not essential to life; there are undoubtedly three well-marked changes which follow hypophysectomy; the first change concerns the pancreas. We have not worked very extensively with the question of sugar tolerance and therefore have nothing to say. It is evident that such a study can only be made by determining the individual sugar tolerance before operation and obtaining an index by this means as to the normal carbohydrate tolerance of the individual animal. The second change is the atrophy of the testicles, which is of very early appearance, being extremely marked by the end of the second week after operation. Whether or not this atrophy can be compensated for by the function of some part left behind or of some glandular rests which have been described by Cushing in the floor of the sella turcica, we cannot say. Increase in weight is of late appearance, and whether it be due to the loss of the hypophysis primarily or due to the secondary atrophy of the testicle is not at all clear in our minds.

Our results agree with the most recent work on the subject reported by Aschner, except perhaps in two particulars. He worked almost exclusively with young animals, and inclines to the belief that the removal of the hypophysis from the adult dog is without effect. In the second place he ascribes the atrophy of the testicles to injury of the tuber cinereum. This point of view seems to us a purely academic one. There can

be no agreement as to where tuber cinereum ends and infundibulum begins. We have found no evidence whatever in our work which would incline us to agree with him in this particular.

We are presenting this paper at the present time for two reasons: First, we believe that the question of the essential or non-essential nature of the hypophysis is an important surgical matter, and from the results of our work we believe that the entire gland can be removed without danger to life. In the second place, from our work we believe that there is but one surgical indication for operating, namely, intracranial pressure. If such experimental experience is of any value when applied to clinical questions it is our further belief that the intracranial method of approach is to be preferred to any other method, and that the method of operation in human cases which has been elaborated by Frazier is undoubtedly the most correct from the point of view of anatomy and of surgical technic.

CONSECUTIVE DISPLACEMENT OF THE CEREBRAL HEMISPHERE IN THE LOCALIZATION AND REMOVAL OF INTRACEREBRAL TUMORS AND HEMORRHAGES (APOPLECTIC HEMORRHAGES AND CLOTS).

WITH A DESCRIPTION OF THE OPERATIVE TECHNIC.

BY WILLIAM H. HUDSON, M.D.,

OF ATLANTA, GA.

TUMORS.

In 1908 I operated on a gentleman, aged forty-seven, who presented the typical symptoms of a tumor occupying the motor cortex involving the leg and arm centres.

An osteoplastic approach to the brain was made, the legs of the flap measuring about 3½ inches. The symptoms were in no way urgent or distressing, so that the great amount of intracranial pressure evinced, when the bone was raised, was somewhat surprising. When the dural flap was made and the cortex exposed, no tumor was discoverable on the most careful palpation. The brain was not incised in the search for the tumor, as it was expected that the patient's condition would improve from the relief from pressure, and that the tumor would be shown up at the secondary operation some twelve days later, in the exposed brain area, having been forced toward the cortex by the pressure.

To my surprise and disappointment this patient died at the expiration of 48 hours, this being the only case out of more than 150 brain operations in which, strictly speaking, there was an operative death.

I removed the brain immediately after death, and carefully floated it into a bucket of cold saturated salt solution, the bottom of the bucket having previously been nested with cotton. About two hours after the autopsy the brain was carefully examined and two conditions, especially, carefully noted: first, the *great amount* of damage done the hemisphere by being forced into the operative opening in the bone by the increased intracranial pres-

sure; second, the tumor, which was located in the centre of the operative opening and about three-quarters of an inch below the cortex, became clearly palpable with the finger-tips when the tension had been released by the removal of brain from the skull.

From this case the principles presented here have been developed.

The surgery of the cerebellum, which had been the most unpromising field of cranial surgery, has been transformed into the most successful by improvement in instruments and by the making of an operative approach to the cerebellum which releases the pressure in the entire cerebellar fossa.

A study of Fig. 1 will show that the entire cerebral hemisphere may be displaced in a backward direction, as shown by the long arrows. From this mechanical principle a decompression operation heretofore described (ANNALS OF SURGERY, May, 1912), and the method of operating for intracerebral tumors and hemorrhages herein described have been evolved.

In Fig. 2 are shown three cases of deeply located tumors. In the first three figures on the left, each indicated by (A), is the pre-operative localization of the tumors. In the middle figures indicated by (B) are shown the primary operative approaches to the brain in which instances no tumors were clearly palpable. Under (C) are shown the tumors made palpable and outlined by the second exposure of the brain releasing the hemisphere.

Without going further into details as to cases of tumors, I shall proceed directly to the description of the operative approach to the cortex, which from my present experience seems best.

We will take first a case in which a tumor has been localized in the motor region: First, the usual motor flap is made, as indicated in Fig. 3. No tumor is found. Then the second flap releasing the hemisphere is made. If the tumor has developed to any considerable size it will, most probably, be localized by the finger-tips. In the instance where two flaps

have been made, the area of brain exposed is shown in Fig. 4.

If the tumor has been located in the parietal region, a single bone flap whose anterior border is a line directly upward from the condyle will be sufficient to expose the proper brain area.

In Fig. 4 is shown the method of opening the dura where the tumor is in the central area of the brain: First, the ordinary dural flap indicated by A and A is made. Second, if more pressure must be released, an additional straight incision is made in the dura indicated by B and B, which releases the hemisphere in a backward direction.

In Fig. 1 two small arrows indicate the direction in which the frontal lobe may be released; and in Fig. 5 is shown the exposure of the frontal lobe. The posterior border, if thought best, may be carried backward an inch, or any distance deemed advantageous. In Fig. 6 is shown the posterior releasing bone flap in operations on the temporal regions.

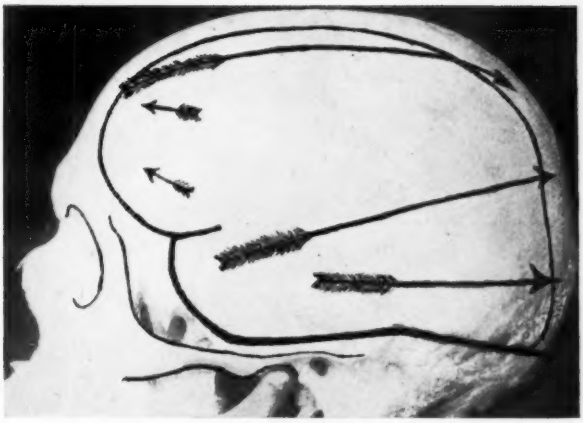
Advantages to be gained: A more accurate localization of the tumor; the operation can be carried out in a much more satisfactory manner; the tension is distributed in such way as to be greatly minimized; and in reality this tension is the most potent factor in preventing the proper surgical procedure.

HEMORRHAGES.

In 1911 I received a hurried call at 2 P.M. In twelve minutes the hospital was reached. The house surgeon gave me the following history as we went together to the patient's room: A man of previous good health, forty-five years old, had been in the hospital two weeks. There had been a slight paralysis of the patient's right side, which had slowly progressed during this period. On the previous day at 11 o'clock he had suddenly raised himself in bed, after which he grew worse with the usual symptoms of an intracerebral hemorrhage. He was entirely unconscious during the night, and it appeared that he would certainly die during the morning preceding the afternoon of my first visit.

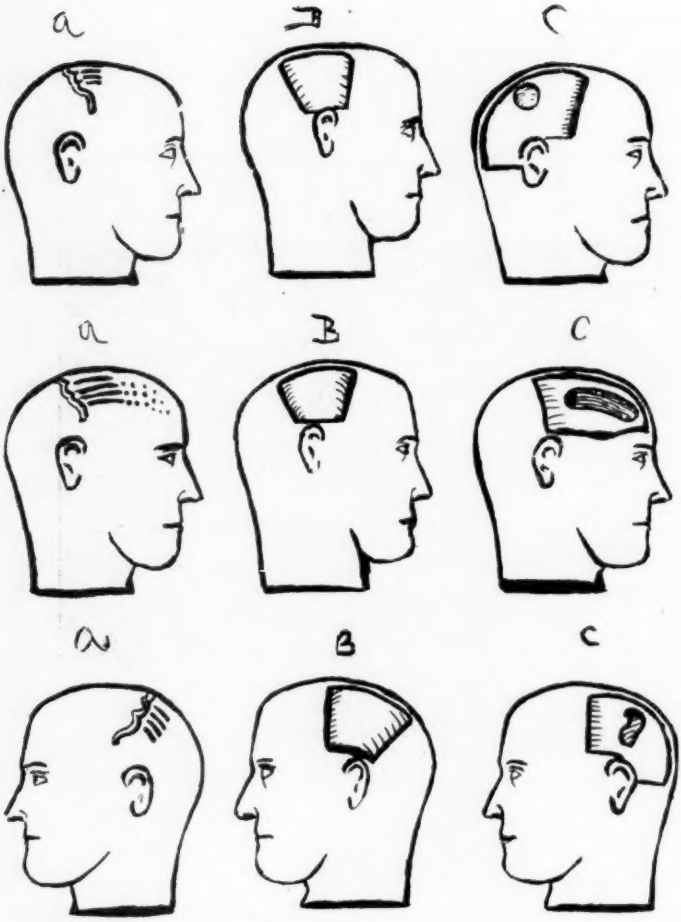
I immediately ordered his head shaved and his removal to the

FIG. 1.



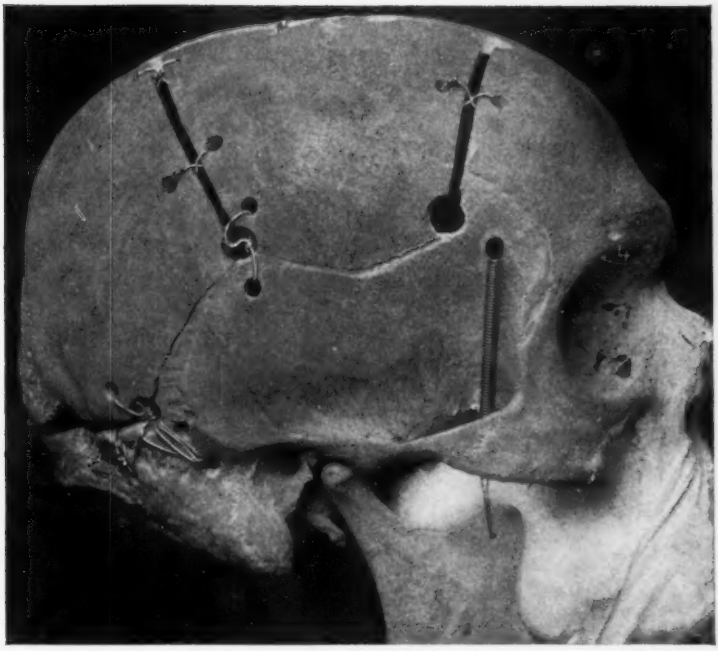
Shows by the long arrow the direction in which the pressure within the cerebral hemisphere may be released, by the consecutive backward displacement of the hemisphere. The short arrows show the direction of displacement of the frontal lobe when only the frontal lobe is to be exposed.

FIG 2



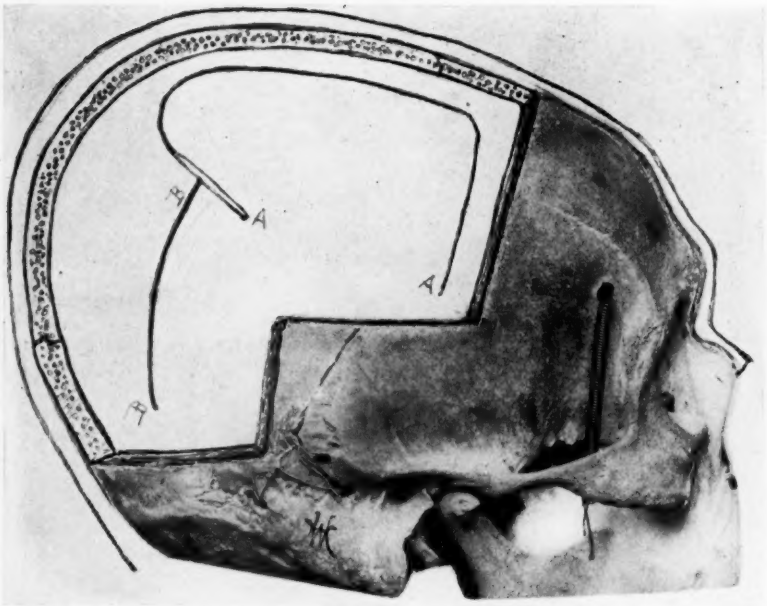
Represents the localization of intracerebral tumors by palpation when the pressure has been released.

FIG. 3.



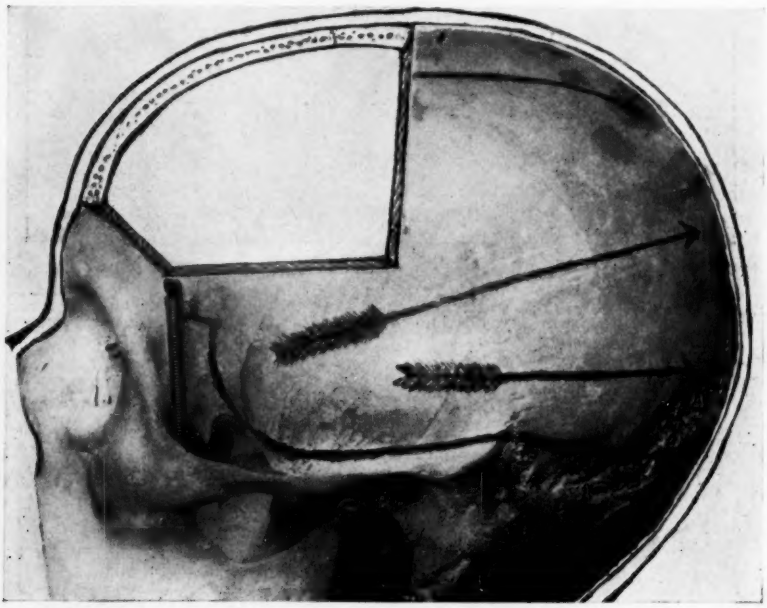
Represents the exposure of the hemisphere by two bone flaps, when the exposure of the motor region shows the tumor to be deeply located. The second posterior bone flap is made to release the tension in the hemisphere. The expanding wire sutures are also shown looped down. When possible to know beforehand only one bone flap should be made.

FIG. 4



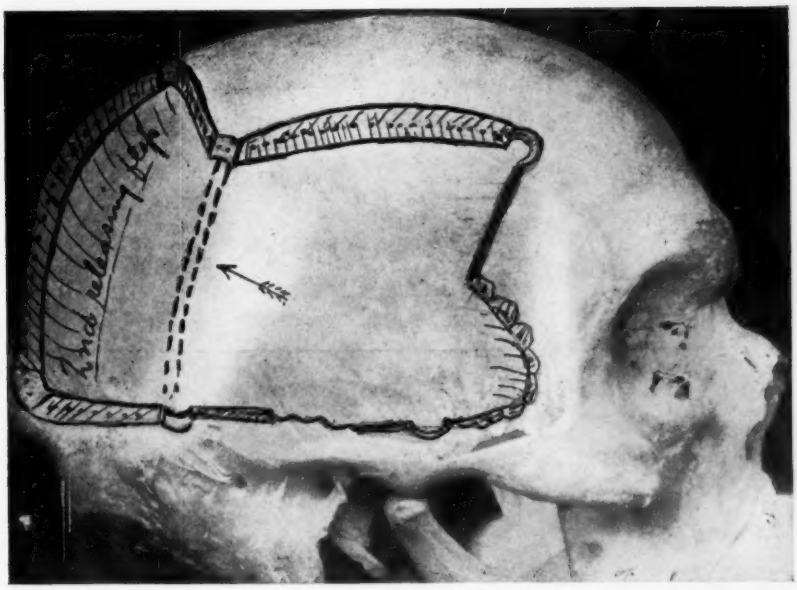
Shows the incisions in the dura after it has been necessary to expose the hemisphere by two bone flaps. The first dural flap may be reversed if necessary. The brain guard may be used in the up and down incision, if it is deemed best not to allow the brain to escape. This area of brain may be exposed by a single bone flap.

FIG. 5.



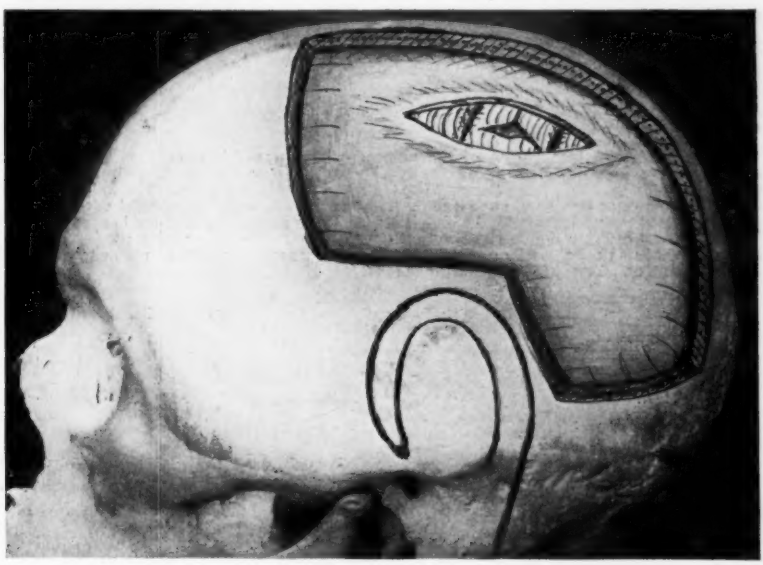
Represents the exposure of the frontal lobe in such a way as to release intracerebral pressure. Bone flap may extend further in a posterior and downward direction if necessary.

FIG. 6.



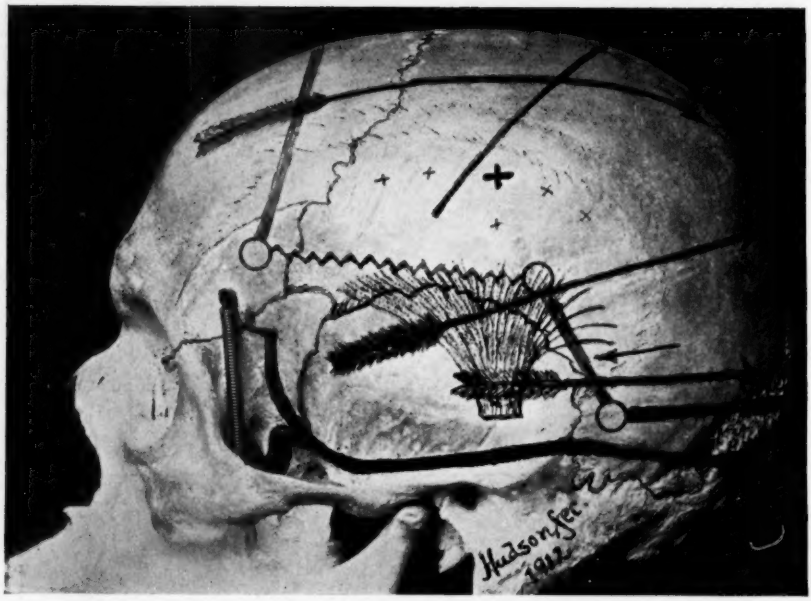
Shows the exposure of the temporal lobe with the addition of the tension releasing posterior bone flap. The bone is cut just above the insertion of the temporal muscle. Trephine openings are made just above the zygoma in front of the ear and at the usual point behind the ear The fibres of the temporal muscles are separated at the anterior border of the flap and the bone cut under the muscle and scalp in such way that the breaking of the base of the flap will take place low down. The bone anterior to the front margin of the bone flap may be cut away if more space is needed. The upper border of first bone flap may be extended to a point nearer the middle line of the head, giving additional room.

FIG. 7.



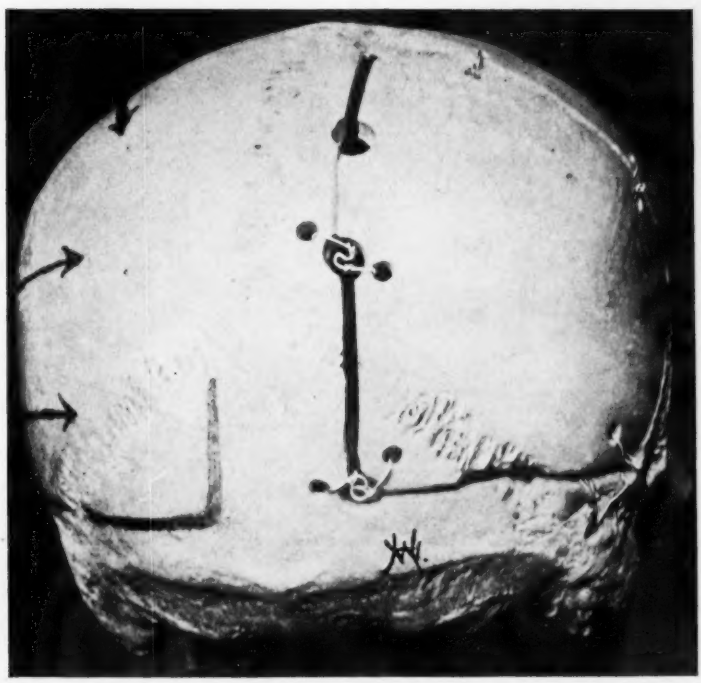
Area of brain exposed in operation for intracerebral hemorrhage.

FIG. 8.



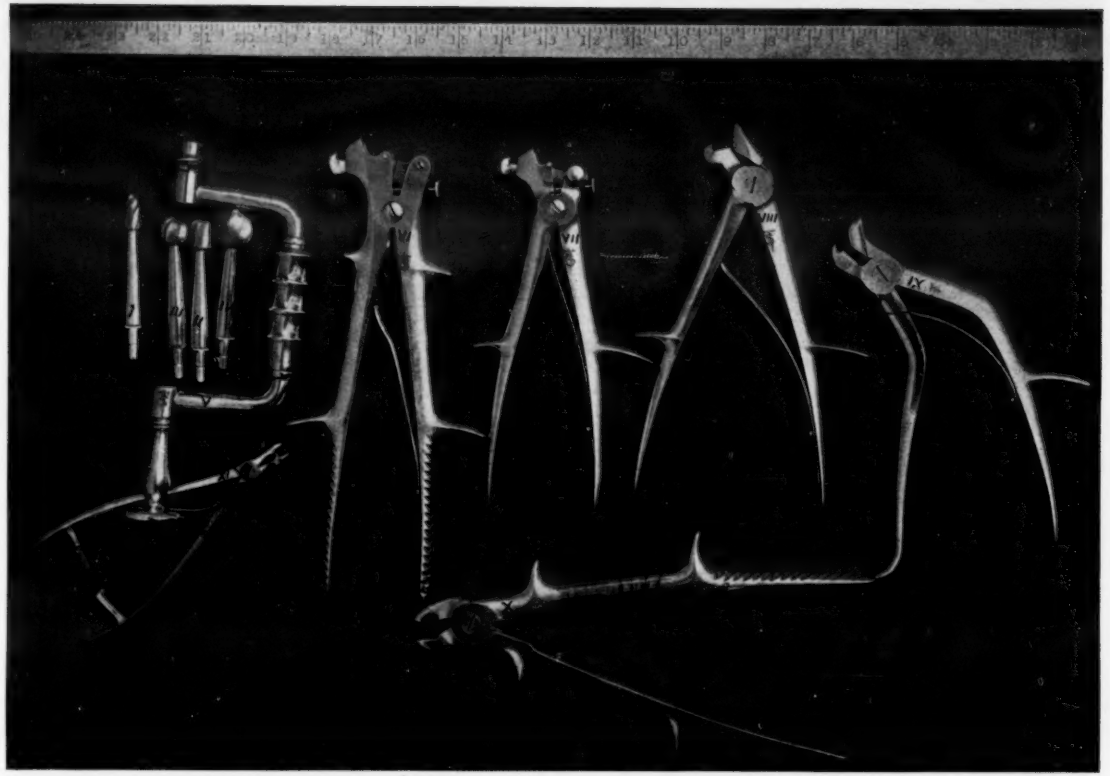
A study for the localization of the points to be observed in operations for intracerebral hemorrhages, and the outlines of the bone flap in exposing the brain. The short arrow points to the channel cut in the bone beneath the temporal muscle and scalp. The solid line in front, the extreme anterior border of such a flap. The broken line running parallel with the coronal suture indicates the position behind which it is not safe to make the anterior border of the flap. The large cross directly above the external opening of the ear and within the insertion of the temporal muscle is the point for puncturing the brain in search for the large majority of intracerebral hemorrhages. The sheaf-like markings represent the internal capsule.

FIG. 9.



Shows a large bone flap fastened down by the application of the expanding silver suture. This is necessary if the tumor has not been removed or will recur, or, if the hemorrhage has not been found and evacuated.

FIG. 10.



Author's armamentarium for cranial attack in the operations here described.

operating room. At 2.30 o'clock the operation was begun. The anæsthetist was ready, but no ether was required. Oxygen would have been administered, but breathing failed and artificial breathing was attempted. The brain was rapidly exposed, as indicated by Fig. 7. An immediate backward displacement of the brain was observed; and the patient began to breathe. A hurried palpation of the dura showed a point which appeared more prominent than any other. Through this point the dura was incised, when immediately the cortex in the apex of a convolution ruptured; several clots of blood and a quantity of fluid blood were forcibly thrown out. At this point the patient's condition had so improved that more deliberation was possible. The hemorrhage from the cavity in the brain was quite profuse, but was eventually controlled with bits of dry cotton. The dura was not closed and the finger of a rubber glove was caught with a stitch of fine catgut in the lower border of the dura. The brain at this point occupied its normal position within the dura, the abnormal tension produced by the hemorrhage having apparently disappeared. The bone flap was closed down and the scalp closed, the rubber drainage being brought out through an original trephine opening in the skull and the original incision in the dura. The hemorrhage was rather free for three or four days and continued until the eighth, necessitating daily changes of dressing. The patient rapidly recovered and was walking about the hospital from the fourth to the twelfth day, when he left.

I have performed quite a large number of operations for various kinds of intracranial hemorrhages, but the one here described is the only one pertinent to the present article; and from that case the technic for the removal of intracerebral hemorrhages as herein described has been evolved.

A broader experience in my hands and in the hands of others may suggest many important changes; but as increased pressure in such cases has been the factor which has prevented an efficient technic, and as that increased pressure, by the method here described, is better controlled, it is believed that this is the foundation for a successful operative treatment of all forms of intracerebral hemorrhages when the successful evacuation of such hemorrhages may result in recovery.

It is believed that it is necessary that the brain should be invariably exposed over a large area, and in such a manner as to permit of the consecutive displacement of the entire hemisphere, and that only one bone flap should be made, the anterior border of which should generally be represented by a line running straight upward from a point just in front of the condyle of the lower jaw.

According to pathologists fully 50 per cent. of intracerebral hemorrhages involve the internal capsule; therefore a point about two inches above the external opening of the ear, and posterior to the fissure of Rolando, should be selected for puncturing the brain in the search for the hemorrhage. No opening in the dura, however, should be made until all aid possible has been gotten by palpating the exposed area of brain with the dura intact. Should any portion of brain be found more protuberant or denser than any other, this, perhaps, should be the point of puncture.

Operative Technic.—It is necessary, where the exposure of the brain is made in such way as to allow the displacement of the hemisphere, to make several openings in the skull and to cut long channels. This work must be done quickly and easily, and in such manner that the patient receives the smallest possible amount of shock and jar. And it is also necessary that the surgeon's fingers and hands are not fatigued, or his sense of touch interfered with. This requires an entirely new surgical armamentarium, represented by self-stopping trephines and powerful two-hand channel-cutting forceps, and many other new instruments for cranial surgery.

In making the large bone flap, as shown in Fig. 7, the preservation of the scalp must be considered; and the solid line in Fig. 8, indicated by the small arrow, is cut under the temporal muscle and scalp.

First the head is shaved and disinfected after some reliable process, the writer preferring the final corrosive sublimate alcohol application, being very careful that none of this solution is gotten into the patient's eyes. Several primary openings are made outlining the bone flap; two short bevels

about three-quarters of an inch long are made at suitable points with the finest Gigli wire saw. The rest of the flap is made by cutting a channel about one-eighth of an inch wide around the bone flap. To properly control the bleeding in the bone it is necessary that this channel be at least one-eighth of an inch wide to allow the proper insertion of bone wax should bleeding occur. Where the bone is cut with a saw, bleeding is very common. Where it is cut with forceps, I have never seen a profuse hemorrhage, as the diploë of the bone is tightly closed by the crushing action of the forceps. In one case of my own a large venous sinus one inch in length was entirely closed so that not a drop of blood escaped. This was discovered by a later removal of a small strip of bone. After the bone flap has been outlined it is carefully tried with the lever ends of the dural separators. If the base does not readily break it is weakened by cutting under the temporal muscle and scalp, or scalp on both sides, until the breaking is easily accomplished. There may be many points of troublesome bleeding on the surface of the dura. These are best stopped by cutting small pieces of the temporal muscles and sticking them over the bleeding points until they adhere.

In opening the dura for tumors, various incisions may be demanded which are explained in the pictures. In opening the dura for intracerebral hemorrhage, great care should be used; the cortex carefully protected, the brain not being allowed to escape from the dura, if it is possible to prevent it.

In a case in which an apoplectic clot has been evacuated, the dura should be carefully closed if possible; but in all cases drain. It is best to drain the cavity in the brain with a soft strip of rubber tissue, but the tissue should not extend to the bleeding vessel. A small trephine opening may be made in the bone flap for the drainage. At the most suitable angle of the dural opening a piece of rubber is stitched for subdural drainage. Later these drainage points are repaired, if necessary.

In the case of unremovable tumors, the bone flap is fixed down with the expanding wire suture, the same method to be

applied where the operation failed to find and remove the blood clot.

It is my practice in many cases to fix the bone flap back with silver wire sutures. To do this it is necessary to make small drill holes in both sides of the bone. This is best done by grasping the bone with a drill guide as shown in Fig. 9.

The best method of closing the dura is with fine curved needles and fine silk applied as interrupted sutures; but in these cases as time is important the fine silk is applied in continuous suture, the silk having been sterilized in vaseline. When the scalp flap is made two nicks are made in the free border on both sides so that the flap may be accurately adjusted in closing. The closure must also be quickly done and two long needles are used. Fine silk is the suture material used. The two needles are inserted together about three-sixteenths of an inch apart. They go entirely through the thickness of the scalp. No. 1 is first tied while No. 2 remains in the scalp. No. 1 is then advanced beyond No. 2 and inserted through the scalp again. No. 2 is pulled through and the silk thread tied. This is repeated until the entire scalp wound is closed.

This method prevents the inversion of the edges of the scalp and allows the taking of the entire thickness of the scalp within the grasp of each ligature, so that no blood-vessels in the entire incised scalp require tying. The method is very quick and satisfactory.

The methods and details have been accurately pictured and described. The method in its entirety must be followed until better methods have been developed, if the best results are to be obtained.

DESCRIPTIVE LEGENDS OF ARMAMENTARIUM.

Figs. from 1 to 4, inclusive, are the self-stopping burrs.

Fig. 5 is a hand brace for driving these burrs.

The writer frequently makes from six to ten primary openings in the skull, these openings serving as safety stations, and to expedite the cutting of the channels in the bone which outline the large bone flaps.

These trephining burrs, to the untaught, *superficially* resemble burrs that have been in use many years. They differ from the ancient trephining burrs in possessing a new quality by which they stop automatically just where they should stop when the holes are being made through the bone. They are the result of the writer's discovery of a new mechanical principle; and the first *really new* trephining instruments that he knows of.

In cutting narrow channels in the skull, saws, whether straight or circular, hand- or power-driven, are not permissible. They open up the blood channels in the bone, making it very difficult to control the bleeding from the bone; besides, it is impossible to cut down upon the dura safely with the saw. The proper method of making narrow channels in the skull is with powerful crushing forceps, cutting from within outward. The portion of the skull that may bleed when cut is the part which contains the diploë. When this portion of the skull is cut with crushing forceps, the internal plate of the bone is broken through and pushed against the external plate; by this act the blood-vessels are closed, and in addition to the blood-vessels being closed the semifluid elements in the portion of bone and diploë which has been broken through are forced into the surrounding bone, acting as a bone wax, effectually stopping the hemorrhage.

Fig. 6 shows a powerful two-hand channel-cutting forceps, cutting out a channel in the bone three-sixteenths of an inch wide, and cutting each inch of channel in five strokes. These forceps are necessary where the brain may be left decompressed. The width of channel made by these forceps is the proper one for such an operation.

Fig. 7 is a one-hand form of these forceps cutting, a channel 3/32 of an inch wide, and should be used where a simple osteoplastic flap is made. These forceps should not be confused with the forceps of the Dahlgren type, as they act upon a different mechanical principle and are very much more effectual.

Fig. 8 shows a channel-cutting forceps cutting upon en-

tirely *new* mechanical principles as applied to bone forceps, which render forceps of this type a vast improvement on all previously used. They are especially necessary in making channels *under* the muscles of skull and scalp, where these tissues must be preserved, and where the bone must be weakened before its base can be broken.

Fig. 9 is a forceps cutting upon the same principle as Fig. 8, only that it has a very shallow foot for use where the intracranial pressure is very much increased, and where it is not wise to press more than very slightly upon the brain.

Fig. 10 is a powerful two-hand forceps embodying the same mechanical principle for the permanent removal of bone, wherever this may be desirable in any brain operation.

Fig. 11 is a needle holder for fine half circle needles and silver wire clip forceps combined. With these forceps the sewing of dura and brain can be done, or the silver wire clips applied to bleeding vessels, both combined in the same instruments.

It is the writer's belief that the surgery of the brain, which is the tap root of the tree of surgery, has failed to advance on account of the surgical tools by which this surgery was attempted being entirely inadequate for this work. He further believes that, with the thorough understanding and the proper application of this means and by observing these methods of doing cranial surgery, the purely mechanical procedures are rendered as easy, quick, and safe as in abdominal surgery.

It has been the purpose of the writer to perfect methods which would not only decrease shock to the patient but render the work so easy that the surgeon's hands would not be fatigued or his reflexes benumbed by the actual performance of the operation. To do this it has been necessary to develop an armamentarium much more extensive than any heretofore in use for the surgery of the brain, but in which there is nothing superfluous, if the work is to be carried out to its most perfect measure.

COEXISTING INFECTION AND SARCOMA OF THE THYROID.*

BY MILES F. PORTER, M.D.,

OF FORT WAYNE, INDIANA.

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SARCOMA of the thyroid is a rare disease, and sarcoma of the thyroid complicated by infection still more rare.

Müller and Speese [1] found only 11 cases of sarcoma recorded in the literature of this country prior to June, 1906. Only 11 per cent. of these cases occurred in patients under thirty. In 53 per cent. of malignant disease of the thyroid, sarcoma and carcinoma, they found a previous history of goitre, and in more than half the cases this history extended over a period of more than ten years. Two-thirds of the cases were in women and 53 per cent. of the cases occurred between the ages of forty and sixty. They found adenocarcinoma and round- and spindle-cell sarcoma the most frequent types. Metastasis involves the lungs and bones most commonly and of the latter especially the skull and inferior maxilla.

They report that carcinoma of the thyroid invades distant parts by way of the blood-vessels, and sarcoma through the lymphatics with greater frequency than is the general rule. Malignant goitre caused death in 70 per cent. of the cases reported by them. I have made quite an extended but not exhaustive search of the literature, but have succeeded in finding only four cases beside my own of sarcoma of the thyroid reported since 1906.

E. A. VANDERVEER,[2] of Albany, reported a case of sarcoma of the thyroid in 1907 occurring in a male aged 70. He gave a history of

* Read before the Western Surgical Association, December, 1912.

[1] Univ. of Penn. Med. Bulletin, Philadelphia, June, 1906; Abs. Jour. A. M. A., vol. xlvii, 1906, p. 72.

[2] ANNALS OF SURGERY, vol. xlvi, p. 829, 1907.

goitre extending over a period of six years. The growth was the size of two oranges, symmetrical, movable, and painless. A diagnosis of cyst of the right lobe was made and the growth removed under local anæsthesia. There were many adhesions and much hemorrhage. The man recovered and left the hospital at the end of 21 days with the wound healed. The laboratory report was fibrosarcoma.

NASETTE[3] reports a case of sarcoma of the thyroid as a recurrence of carcinoma, but I could not obtain even an abstract of his article for the present paper.

KOCHER says that sarcoma (aside from endothelioma) and carcinoma may occur in the thyroid at the same time, but that the combination is rare. He further says that it is remarkable that this combination has apparently been observed beyond the possibility of a doubt only in cases in which there was some doubt that the epithelial tumor in the thyroid was primary.

CHAVANEZ and PIERRE NADAL[4] report a case of tumor of the thyroid in a woman 64 years old, which was removed after it had existed a "long time," and which upon microscopic examination was found to contain sarcomatous areas together with ostoid, chondroid, and ordinary connective-tissue areas.

W. H. SNYDER,[5] of Kalamazoo, reports a case of sarcoma of the mediastinum which invaded the thyroid. The patient was a male aged 37. The symptoms, cough, difficult breathing, and hoarseness, antedated the appearance of the thyroid tumor three months. The tumor was very hard. One month after the first appearance of the thyroid tumor it was removed by operation. The cervical lymph-glands were also involved. The patient died 41 days after the operation from increasing obstruction to breathing and weakness. At the autopsy the tumor was found adherent to all neighboring organs except the left lung. No metastases were found outside of the mediastinum and neck. The specimen was submitted to Dr. A. S. Warthin, of Ann Arbor, who reported as follows:

"The growth is a round-cell sarcoma, the majority of the cells being of the large round-cell type. There is no evidence of any leucæmic condition in the blood-vessels, and unless the process was localized in the lymph-nodes as a primary condition the tumor should be classed with the simple sarcomata. The thyroid is invaded, and there is no subpleural metastasis invading the lung tissue. If the lymph-nodes were the seat of the tumor process, the condition would fall into the group of aleucæmic, large-celled lymphosarcoma."

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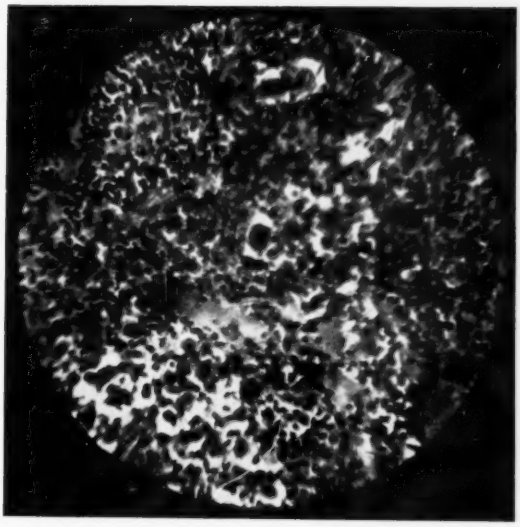
[3] Policlinico, Rome, Oct., 1909, xvl, No. 10, 429–476; Jour. A. M. A., vol. liii, p. 1871, 1909 (only title given).

[4] Jour. de med. de Bordeaux, 1910, 51, p. 817; Abs. in Jahresbericht für Chirurgie, 1, 1910, p. 683.

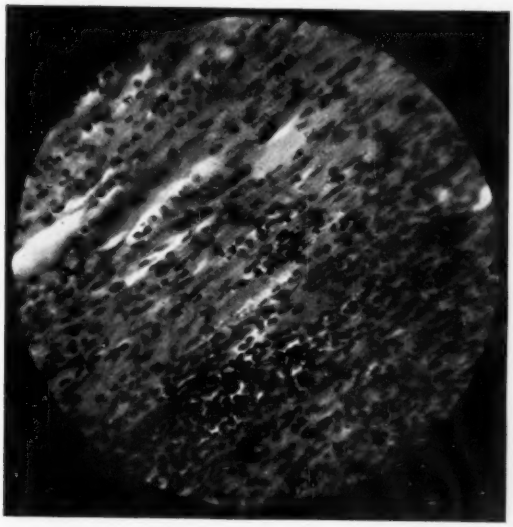
[5] Jour. A. M. A., vol. l, p. 766, 1908.

FIG. 1.



Author's case, showing leucocytic infiltration and occasional giant cell. Note absence of thyroid tissue. Rhamy ⅛ obj.

FIG. 2.



Author's case, showing spindle cells with leucocytic infiltration. Note absence of gland tissue. Rhamy ⅛ obj.

My own case is as follows:

S. B., male, aged 12, admitted to Hope Hospital, Sept. 5, 1912. Family history good. Never been ill until present trouble came on ten weeks ago. At this time he noticed a small lump on the front of the neck just above the end of the sternum. This has been growing, and there also appeared lately a small lump above and to the left of the original.

Examination showed a well-nourished blond lad with a goitre the size of a lemon which seemed to involve equally all parts of the gland. The skin was not discolored nor attached to the goitre, which was very firm, not nodular, slightly tender, and not painful. Above and to the left of the goitre there was a somewhat tender lymph-gland as large as the end of my thumb. This gland was freely movable. Urine was negative. The blood showed 20,200 white cells, with 74 per cent. polynuclears. The temperature ranged from normal to 100.6° F. There were no symptoms of hyperthyroidism. At times there was some choking sensation. Slight headache. Appetite poor. Bowels regular. It was thought that the trouble might be entirely inflammatory, although the probability of malignancy was recognized. Operation was advised and accepted.

On Sept. 10, five days after admission, the usual collar incision was made under ether. It was found impossible to separate the muscles and fascia from the surface of the goitre, save by cutting, on account of the dense adhesions. The gland structure was yellowish gray in color, not vascular, firm, and somewhat friable. That portion of the gland immediately overlying the trachea was removed, a drain inserted and the skin wound closed up to the drain. The wound healed promptly and the boy left the hospital 16 days after the operation.

Dr. Rhamy's report is as follows:

"After a careful study of the sections from the thyroid of L. B., I find that beneath the very marked inflammatory infiltration there is undoubtedly a spindle-cell sarcoma. This shows plainly in areas where there is little leucocytic infiltration. In the greater part of the growth, however, the leucocytic infiltration is so intense that the sarcomatous growth can only be made out in the light of the other fields which do show it plainly. Nowhere in the growth can I find any recognizable thyroid structure" (Figs. 1 and 2). It is important to say here that the report on the frozen section made at time of operation was that the trouble was inflammatory.

He also states in a subsequent communication that both cultures and smears demonstrated a staphylococcus infection. The report from the Columbus Laboratory is as follows:

"Specimen is made up of embryonal connective tissue that shows little or no tendency to form adult connective tissue. There are a few foci of necrosis. It is a small round-celled sarcoma."

I tried to get a late report from the patient but failed, so I cannot say whether he is still alive or not.

According to Müller and Speese round- and spindle-cell are the most frequent types of sarcoma found in the thyroid. Of the cases collected for this paper there are two in which the type is noted, one fibrosarcoma and one large round-cell sarcoma. In my own case the two pathologists who examined the specimen differed somewhat, the one pronouncing it to be a small round-cell sarcoma and the other classifying it as belonging to the spindle-cell variety. According to Kocher[6] the spindle-cell type is the most common and the large round-cell comes next, while the small round-cell variety, he says, is rare. Spindle-cell sarcomata may be converted into bone or cartilage. The case of Chavanez and Pierre Nadal reported above illustrates this. This author (Kocher) also says the round-cell variety often resembles lymphosarcoma so closely as to make the differentiation difficult. It will be remembered that Warthin in his report on Snyder's case, as noted above, suggests that that may be a lymphosarcoma of the large round-celled type. The complete destruction of the gland tissue by the neoplasm is quite common. It will be remembered in my case Dr. Rhamy was unable to find "recognizable thyroid structure."

The bones are frequent seats of metastatic growths originating from malignant disease of the thyroid. Especially are the sternum ribs and scapulæ apt to be attacked in this way in sarcoma of the thyroid.

Invasion of distant structures by way of the lymphatics from sarcoma originating in the thyroid seems much more common than is the usual rule concerning metastasis in sar-

[6] Keen's Surgery, vol. iii, p. 388.

coma. Had I been better acquainted with this fact I would not have allowed the lymphatic involvement in my case to weigh so heavily as I did in favor of a diagnosis of thyroiditis. Concerning the combination of infection with sarcoma in the thyroid, I could find no case reported. In view of the frequency of infection in malignant growths generally, however, it is fair to presume that the combination is not rare.

There is very little to say concerning the diagnosis of malignant thyroid disease, but it is important, perhaps, to emphasize two or three points.

First, I have a feeling that with malignancy in enlarged thyroids as with malignancy in large prostates the condition is more frequent than it is generally thought to be. This feeling is a result of the systematic and careful examination of all goitres removed by me for the last year or more. As yet I am not able to report in detail.

Second, comparatively sudden and rapid increase in size in an old goitre should arouse suspicion of malignancy, especially if this rapid growth is accompanied by pain.

Third, hemorrhage into an old goitre should raise the question of malignancy.

EXPERIMENTAL DEVASCULARIZATION OF INTESTINE WITH AND WITHOUT MECHANICAL OBSTRUCTION.*

BY J. SHELTON HORSLEY, M.D.,

AND

C. C. COLEMAN, M.D.,

OF RICHMOND, VIRGINIA.

EXPERIMENTAL work on intestinal obstruction has been quite abundant in recent years, yet the subject is at present by no means settled. Much, however, has been learned. The work of Stone, Bernheim and Whipple (*Johns Hopkins Hospital Bulletin*, June, 1912) shows that the theory holding death from obstruction to be due to a toxic product formed in the mucosa is correct. By a series of brilliant experiments they have isolated the toxic principle from the mucosa of the obstructed intestinal loop. They have freed it from germs by the centrifuge and compared it with preparations from the mucosa of a normal intestine. They have checked up their experiments by controls which have been so frequently lacking in other work of this character and have demonstrated that this toxic product is constant in an obstructed loop of bowel when ileus occurs; that it is not due to germs; that it is not found in the mucosa of unobstructed bowel; that it decreases in quantity or virulence from the duodenum to the ileum; that the injection of this material into an animal will cause symptoms of ileus; and, finally, that animals may be rendered partly immune to obstruction by injection of graduated doses.

Just why this toxic product forms in an obstructed loop has not been ascertained. The action of bacteria and the interference with circulation do not seem to have a consistent relation in causing it. It has long been known that the lumen

* Read before the Southern Surgical and Gynecological Association, December 19, 1912.

of the bowel itself might be occluded without producing symptoms of ileus, provided the obstruction was low down in the intestine and the animal was not fed or purged. Hartwell and Hoguet (*Journal A. M. A.*, July 13, 1912) have noted that obstructions high up are not so rapidly fatal if the animal is given salt solution underneath the skin and infer that the early death of a high obstruction is chiefly due to the marked loss of water. This does not entirely agree with the work of Stone and his colleagues, who find that the toxic principle is more potent in the duodenum than when a loop of bowel is obstructed further down.

Our experiments were originally undertaken for the purpose of demonstrating, if possible, the difference in the effect on an animal when the devascularized segments of intestine were obstructed at both ends and when such segments were open and their products allowed to flow freely into normal bowel; but the fate of the obstructed loop eventually became the chief subject of investigation. In all experiments the last portion of the ileum was used. All the animals were dogs, and in each instance they were operated upon under full ether anæsthesia and every precaution taken to prevent pain. There were twelve experiments. Two recent experiments, together with ten that have been previously reported (*Journal A. M. A.*, August 24, 1912), may be summarized as follows:

In each experiment a segment of bowel in the lower ileum was devascularized by cutting the mesentery close to the border of the intestine and ligating the blood-vessels. In five of these experiments tapes were tied at each end of the devascularized segment to obstruct, but not injure, the bowel, and so shut off its lumen from the healthy intestine. In all except the first (dog No. 1) the omentum was wrapped around the intestine. Of the five operations in which tapes were placed on the devascularized segment, two dogs died within 48 hours after the operation from gangrene and perforation of the obstructed segment with peritonitis. One died after three days and two others lived 13 and 14 days, respectively. (See table.) Of the seven dogs in which the mesentery was sep-

arated and the devascularized segment left unobstructed, one died 27 days after the operation from mechanical obstruction from adhesions, another died 28 days after operation from causes not attributable to the operation, and the other five were killed under anæsthesia at periods varying from 15 to 49 days and were apparently healthy at the time of their death. The dog allowed to live longest (No. 12) was in excellent condition when killed 49 days after operation. The specimen showed the bowel well nourished, unobstructed, and apparently normal.

These experiments seem to show that the toxic product is either not formed to any marked degree when a loop of the ileum is completely devascularized, or else if it is formed, the normal mucous membrane does not absorb it. Stone states that it is of low potency in the ileum. According to the experiments of Murphy and Vincent (*Boston M. and S. J.*, November 2, 1911), venous obstruction always adds to the gravity of the situation. We have not attempted anything along this line, but in the seven dogs in which the loop of intestine was completely devascularized without obstruction of the lumen, there was no death that could be attributed directly to the devascularized loop and only two deaths occurred at all—one 27 days after the operation and the other 28 days after operation. Of five dogs in which the loop was both devascularized and obstructed, death in two was due to rupture of the gangrenous segment and general peritonitis, and of the remaining three, one died after three days without rupture of the segment and the other two lived 13 and 14 days, respectively. The death that occurred at three days might possibly have been due to the toxic principle worked out by Stone, but the other two dogs apparently died largely from starvation. Of the seven dogs with devascularized segments without obstruction, it is interesting to note that whatever product was formed in these segments did not apparently influence the health of the dogs, though it could flow freely to the healthy bowel. The most interesting feature, however, is the fact that the bowel in each instance survived and functionated satisfactorily. The technic merely consisted in com-

pletely severing the mesentery close to the bowel, wrapping the omentum around the segment and fastening it with a few stitches.

It has usually been taught that if a bowel is deprived of its nutrition from the mesentery for even a short distance, a resection should be done. These experiments demonstrate that, in the dog at least, a loop of four or five inches of intestine may be deprived of its blood supply through the mesentery and may still survive if omentum is wrapped around it and fastened in position. In long abdominal operations where for some reason the mesentery has been severed from the bowel and the patient's condition does not admit of a resection, it appears justifiable to wrap the omentum around this portion of the bowel and stitch it to itself and the intestine, with a reasonable expectation that the segment will be properly nourished through the omentum.

TABLE 1.—SEPARATION OF MESENTERY WITH TAPES ON DEVASCULARIZED INTESTINE.

No. of Dog.	Number of Inches of Intestine Devascularized, and Operative Notes.	Post-operative Notes.	Length of Life after Operation.	Post-mortem Notes.
1	Eight inches. No omentum wrapped around devascularized segment.	Dog looked sick twenty-four hours after operation; abdomen distended; respiration rapid.	Died after 36 hours.	Large amount of bloody fluid; bowel proximal to tapes greatly distended; omentum adherent to abd. incision but not to intestine; segment of bowel black, jelly-like, with large perforation near proximal tape.
2	Two inches. Omentum wrapped around segment of bowel and fastened with silk sutures.	Dog apparently well for four days; for three days quite sick; then better for three days, when he became worse.	Died after 14 days.	No free fluid but coating of lymph on peritoneum; bowel proximal to tape greatly distended, distal firmly contracted; segment surrounded by densely adherent omentum.
4	Two inches. Operation same as in Dog 2.	Dog appeared very sick from time of operation.	Died after 48 hours.	Large amount of free bloody fluid, marked distention of proximal bowel, contraction of distal; omentum adherent to abd. wall but not to bowel; segment black, jelly-like; large perforation.
5	Two inches. Operation same as in Dog 2.	Dog did well for three days, then appeared very sick for one day; again seemed better until two days before death.	Died after 13 days.	No free fluid; no distention of intestine either above or below tapes; omentum firmly adherent to segment, which showed but little change. The coats of this segment are somewhat discolored and swollen but sharply outlined. Evidently the omentum has preserved the nutrition of the devascularized intestine.
8	Two inches. Operation same as in Dog 2.	Dog appeared quite sick from time of operation.	Died after 3 days.	Small amount free bloody fluid; proximal bowel distended; omentum adherent to segment of bowel, which was dark, reddish and thickened.

TABLE 2.—SEPARATION OF MESENTERY WITHOUT TAPES ON DEVASCULARIZED SEGMENT.

No. of Dog.	Number of Inches of Intestine Devascularized, and Operative Notes.	Post-operative Notes.	Length of Life after Operation.	Post-mortem Notes.
3	Two inches. Omentum wrapped around segment and sutured.	Dog looked sick day after operation; recovered and was better until two days before death; no food.	Died 27 days after operation.	Dog much emaciated; no free fluid in abdomen; segment adherent and in a partial volvulus, causing mechanical obstruction; segment well nourished; intestine above segment dilated and filled with hair for about two inches.
6	Two inches. Omentum wrapped around segment and sutured.	Dog did well; never very sick; no food.	Killed 22 days after operation.	Dog much emaciated; segment very adherent; bowel proximal to segment dilated and contained fecal matter; distal bowel contracted, but contained fecal matter also; segment dilated, very thin, but no perforation.
7	Two inches. Omentum wrapped around segment and sutured.	Dog never appeared sick; no food.	Killed 21 days after operation.	Dog fairly well nourished; segment buried in mass of adherent omentum and mesentery; segment well nourished; no evidence of obstruction.
9	Four and a half inches. Omentum wrapped around segment and sutured.	Dog never very sick; no food for eight days; then food given freely for ten days.	Killed 18 days after operation.	Dog in fair condition; omentum adherent to segment; otherwise there were few adhesions; vessels in adherent omentum much enlarged; nutrition of segment apparently normal; no evidence of obstruction.
10	Four inches. Omentum wrapped around segment and sutured.	Dog never very sick; no food for five days; then food given freely for ten days.	Killed 15 days after operation.	Dog in fair condition; omentum adherent to segment; otherwise very few adhesions; vessels in adherent omentum were enlarged; nutrition of segment good; no evidence of obstruction.
11	Five inches. Omentum wrapped around intestine and sutured beyond borders of devascularized segment.	Food and water given following day, and until dog died.	Died 28 days after operation.	Dog emaciated, weight about same as at operation. Omentum adherent over devascularized segment. No distention or obstruction at any point. Vessels of adherent omentum enlarged. Cause of death not ascertained. Nutrition of segment apparently good.
12	Four and a half inches. Omentum wrapped around intestine and sutured beyond borders of devascularized segment.	Food and water given following day and until dog was killed. Recovery uneventful.	Killed 49 days after operation.	Dog in excellent condition—had gained in weight. Omentum densely adherent to segment. No obstruction. Vessels of adherent omentum enlarged, as shown in specimen and photographs.

THE SURGERY OF THE SINGLE AND HORSESHOE KIDNEY.*

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THE fact that developmental abnormalities of the genito-urinary system are the most frequent of any part of the body is not generally appreciated. Those involving irregularities of the circulation of the kidney are the most common of this group.

It is necessary for the surgeon of to-day to understand thoroughly these anomalies and he is also much concerned over the functional activity of the kidney, not alone because of operations upon the organ itself, but also because of its great bearing upon all surgical operations.

A brief study of the early development of the genito-urinary system during the first few weeks of intra-uterine life simplifies our understanding of the common and curious derangements of the anatomy of this tract. Early in the life of the embryo the cloaca represents both the future rectum and the bladder. It gradually becomes divided by a vertical fold into two compartments, an anterior with which the allantois and the primitive excretory ducts are connected and a posterior which becomes the lower end of the rectum. Entering the cloaca from the dorsal side are the two Wolffian ducts which furnish the parent structures of the renal pelvis and ureters. The Wolffian duct, while developed originally as a part of the pronephros—the forward nephritic organ which is exceedingly rudimentary in the human embryo— is throughout the greater part of its embryonic existence the excretory duct of the Wolffian body or mesonephros. From these two primitive structures is developed most of the genito-urinary system. The beginning of the permanent kidney—metanephros—appears in the human embryo of from 6 to 7 mm. in

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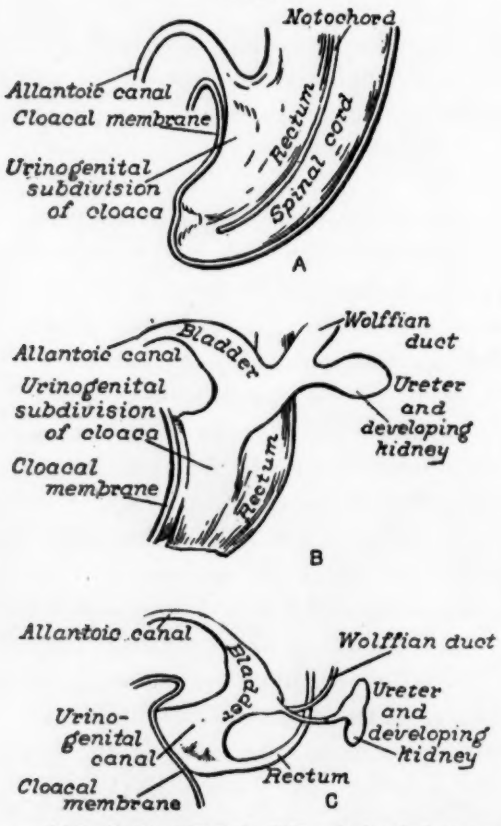
length as a tubular diverticulum formed on the dorsal side of the Wolffian duct near the cloaca. This diverticulum is surrounded from the first by a large group of cells (the renal blastema) which are of mesothelial origin which later form all the secreting portions of the kidney. The tubular portion

FIG. 1.

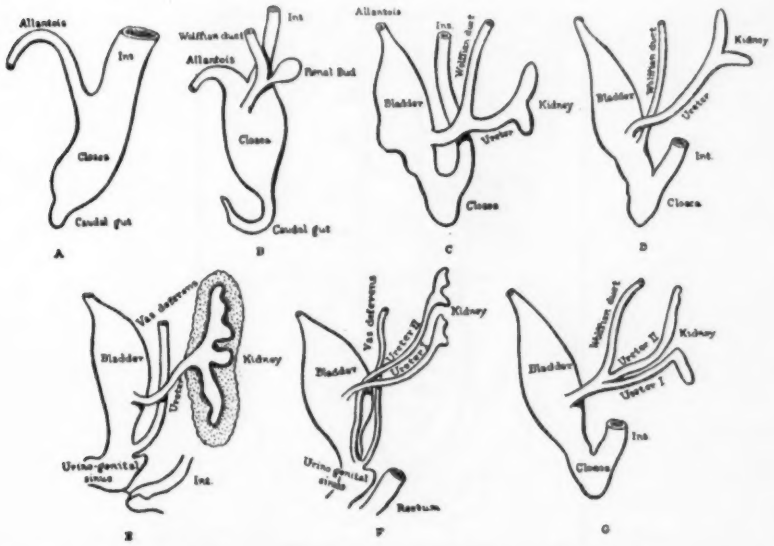


From model by Professor Keibel. ("Cunningham's Anatomy.")

of the diverticulum from the Wolffian duct becomes the ureter, while the distal extremity bifurcates into an upper and lower portion to form the pelvis, or collecting part of the kidney. As the bladder increases in size the single opening of the meso- and metanephros becomes a double one, consisting of the ejaculatory duct at the base of the bladder in the male and the ureter posterior to this (Figs. 1 and 2).

The kidney gradually ascends to the lower dorsal and upper lumbar region. As it ascends it passes and receives its blood supply in succession from the numerous arteries previously developed from the aorta to nourish the mesonephros. As many as five of the branches may be carrying blood to the kidney at once. As the kidney ascends and higher arteries become attached to it the lower ones separate from it. When it reaches its final position one of the arteries enlarges and becomes the permanent renal supply. This is usually the upper

FIG. 2.



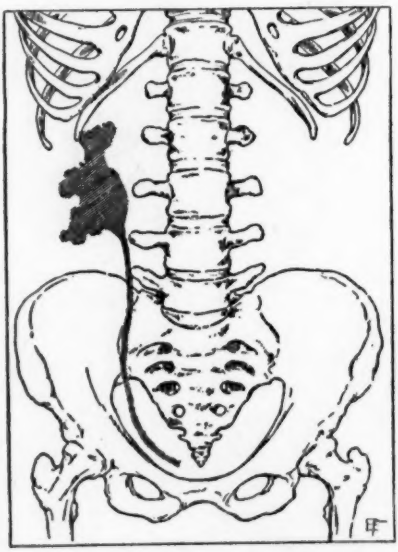
From Dr. George S. Huntington's paper on "The Genetic Interpretation and Surgical Significance of Some Variations of the Genito-Urinary Tract."

member of the lower or the lower member of the middle mesonephric group. Thus in anomalies of position the vessels may arise from the sacralis media, from the common iliac, the inferior mesenteric or along the line of the aorta. If irregularly situated they are usually increased in number. In the division of the kidney into upper and lower portions with separate pelves the division of the vessels permits of the removal of one-half of the organ without injury to the other half. In horseshoe kidney, however, Robinson [1] found 10 out of 60 cases reported with but a single artery branching to

each lateral mass, and 4 cases with a single trunk to the isthmus with one branch to either lateral mass. In such cases the accidental destruction of the blood supply of the entire kidney may easily occur during an operation on it.

There is nothing between the two renal mesenchymal structures during the early development of the kidneys but the forming aorta. Sometimes indeed they are in contact or even fused in front of or posterior to this vessel. This condition persisting, occasions some of the various anomalies

FIG. 3.



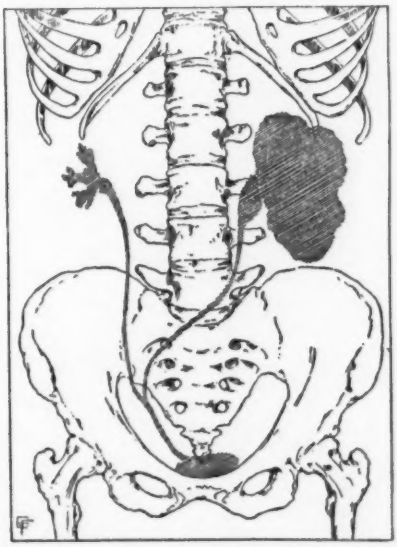
Case No. 5244.—Congenital single kidney.

under discussion. Rarely the secreting substance may become associated with but one collecting portion and ureter and thus there may be but one kidney developed.

We may see the possible development of congenital cystic kidney resulting from a failure of certain portions of the secreting renal tissues to become connected with the collecting portion. Wilson [2] has called attention also to the probable development of the so-called hypernephromata as neoplastic growths from similarly unattached portions of the secreting portion of the kidney. The bifurcation of the end of the

ureter may be so extreme that an upper and lower kidney may be seen on one side with an upper cleft and a lower single ureter, or a complete cleft one, varying according to the point of division of the metanephric diverticulum. The attachment of the secreting substance across the spine may drag one ureter across the midline. Two ureters to one kidney are not uncommon and very rarely three ureters have been found as in the case reported by Bransford Lewis.[3] In the otter each calyx has a short ureter, all delivering through one ureter into

FIG. 4.



Case No. 11,425.—Division of ureter at lower third. Left branch crosses spine and leads to a large hydronephrosis of the left kidney. Right kidney normal.

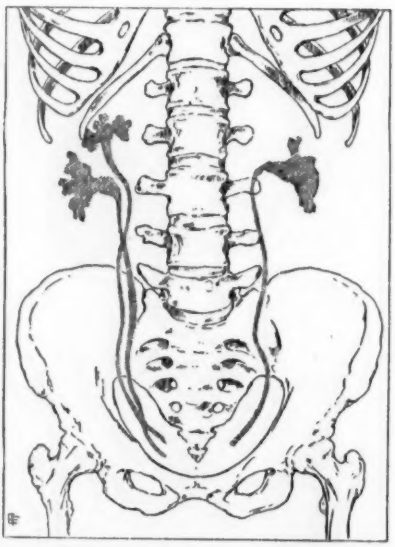
the bladder, a form rarely seen in man. Küster[4] observed the right ureter formed of three branches, two being from the isthmus, while Gebhardt[5] reports one with five branches. We have seen two ureters to one kidney with variously located divisions, in five cases other than in those of the horseshoe type. The openings into the bladder may not be abnormal, depriving us of the aid of the cystoscope alone in making a diagnosis (Figs. 3, 4, 5, 6).

The ureter normally is twelve inches long. In a low placement of the kidney it may still be long and coiled or very

short. Thompson's [6] case of pyonephrosis in a horseshoe kidney had a ureter but one and one-half inches in length.

As to the relative frequency of this anomaly it is difficult to say, since statistics vary so much. Those collected by Thompson [6] show one in 300 autopsies to those of others which place it as seldom as one in a thousand. Our own autopsy records in a single year have shown as high as four per cent. of cases presenting gross anomalies of the kidney or ureter of surgical importance.

FIG. 5.

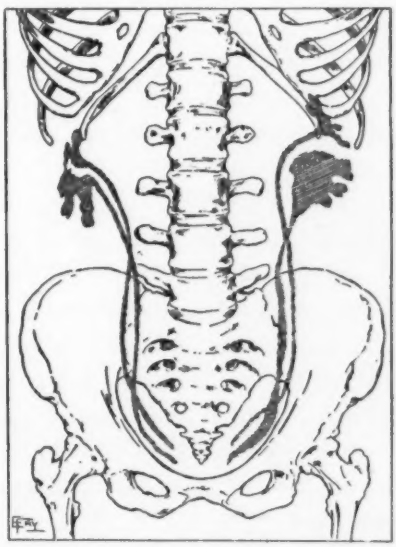


Case No. 10,962.—Duplication of the pelvis of right kidney and ureters. Normal.

Of 36 cases of gross renal and ureteral anomalies observed during five years in our clinic, 7 were found incident to other abdominal operations. Among the total number were 12 of the horseshoe type and 6 of the congenital single or asymmetrical type. During this five-year period, 649 operations were made upon kidneys or ureters. Excluding those diagnosed and not operated on and the cases found at autopsy there was an average of one serious anomaly associated with the disease in every 26 cases, thus showing that such anomalies of kidney and ureter are often the cause of or are a contributing factor to disease of this structure (Figs. 7 to 15).

Robinson's collected statistics show that in the horseshoe form 90 per cent. are fused at the lower poles, and in the others it was reversed, the convex surface being upward. If the positions of the kidney are not symmetrical they are of the "L" shaped or irregularly fused form, the lower kidney being drawn to the midline. At the point of union there may be only connective tissues (in 15 per cent. of the cases); usually, however, it consists of true renal tissue and varies

FIG. 6.



Case No. 13,529.—Bilateral duplication of ureters and pelves. Duplication left kidney pelvis complete, with small hydronephrosis of the lower pelvis. The two pelves of the right kidney united by common calyx.

from a small area to the full width and thickness of the kidney. Robinson found 90 per cent. of cases fused in front of the great vessels.

Among the irregular forms are the sigmoidal—upper and lower pole fused—and the unilateral gross kidney.

Several classifications of horseshoe kidney exist. The oldest grouping by Neufville and Freund [7] admitted form as a criterion, the attachment being at the lower or upper poles. That of Förster [8] was based on the degree of fusion, regardless of the point of attachment. The classification of Heuer [9] was

based on situation and included unilateral and "L" shaped kidneys. That of Carlier and Gerard [10] is based on form and situation. They state that a horseshoe kidney is a congenital malformation consisting in a connection more or less close of two similar poles of the kidneys in front of the spine showing more or less clearly the form of a horseshoe with equal or unequal branches. They divided them into two classes, symmetrical and asymmetrical.

The most common disease affecting horseshoe kidney is hydronephrosis, which later may develop pyonephrosis. Hydronephrosis occurs in moderately young individuals, while pyonephrosis and lithiasis, which also occasionally may be found in horseshoe kidney, are usually seen in middle age or later. All three of these conditions may be present in one side of such a kidney.

Tuberculosis is rarely seen, but when present is diagnosed by the usual symptoms of hæmaturia, disturbance of the bladder, and the finding of tubercle bacilli in the urine. It is located by cystoscopy and the separation of the urine from the two sides. König [11] and Gibbon [12] each report sarcoma of one-half of the kidney in children, both cases recovering from a transperitoneal removal of the growth. Cystic tumors of such kidneys which have necessitated the removal of one-half in one and puncture of cysts in another have been reported by Bockenheimer.[13]

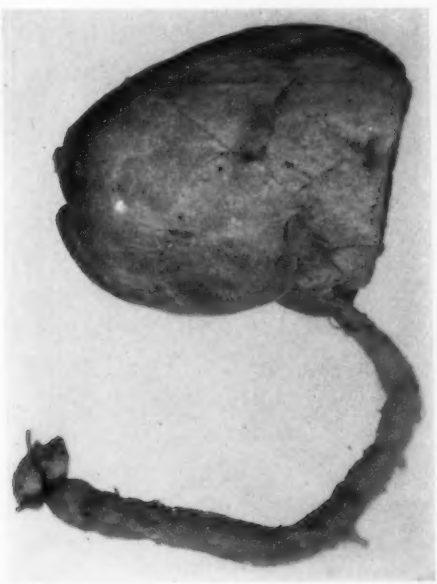
With reference to sex, more horseshoe kidneys are found in women than in men and more single kidneys in men than in women.

For a long time the observations made on horseshoe kidney agreed that the condition could not be discovered save at operation or autopsy, except in those cases where the abnormal kidney attained a pathologic alteration. Since surgical interventions were rare, patients suffering from grave troubles, due to the presence of horseshoe kidney, died without the cause of their symptoms being ascertained. It is very probable that some of these conditions do not produce sufficient disability to cause the patient to consult a physician, especially when the connecting link between the kidneys is connective

FIG. 7.

Exterior of horse-shoe kidney. Note lobulation. Kidney could be easily divided at either interlobular depression.

FIG. 8.

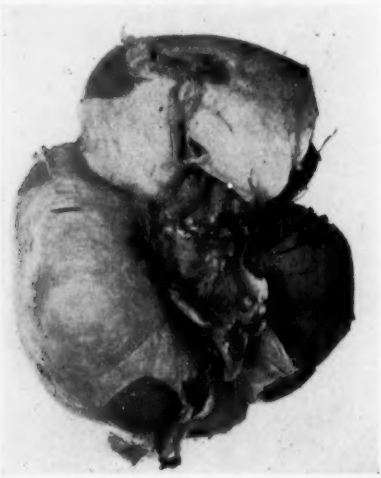


Exterior of horse-shoe kidney with but one ureter. No distinct narrowing between the two halves. (Autopsy specimen.)

FIG. 9.

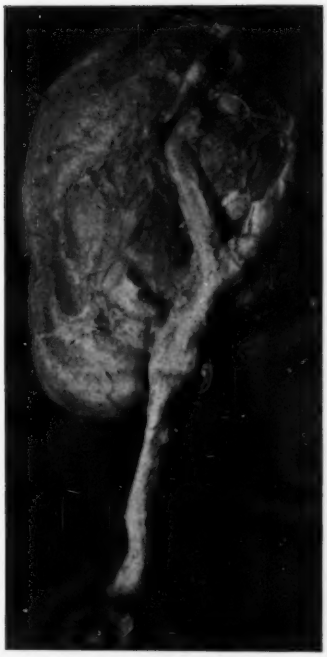
Section of horse-shoe kidney (Fig. 2), showing large hydronephrosis caused by valvular constriction of ureter at ureter-pelvic juncture.

FIG. 10.



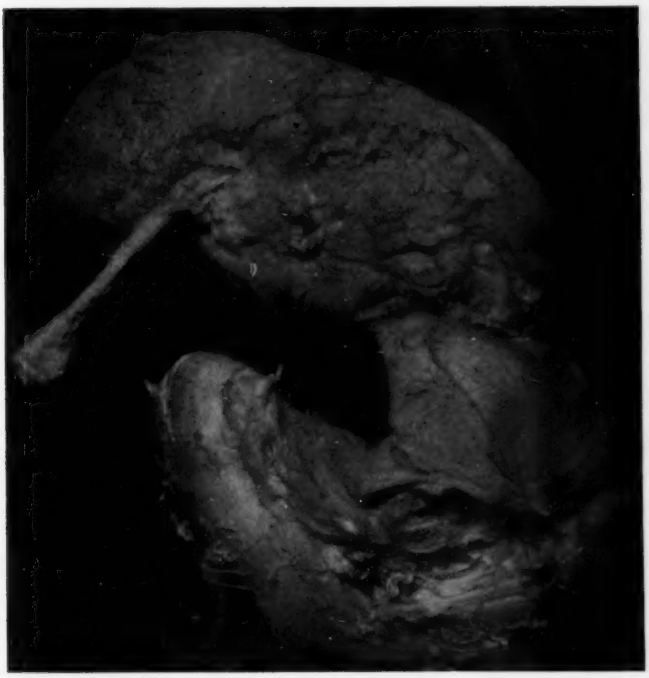
Exterior of one half of horse-shoe kidney with ureter removed at operation.

FIG. 11.



Section of horse-shoe kidney half (Fig. 4), showing (1) large hydro-ureter caused by stone in bladder; (2) pyonephrosis.

FIG. 12.

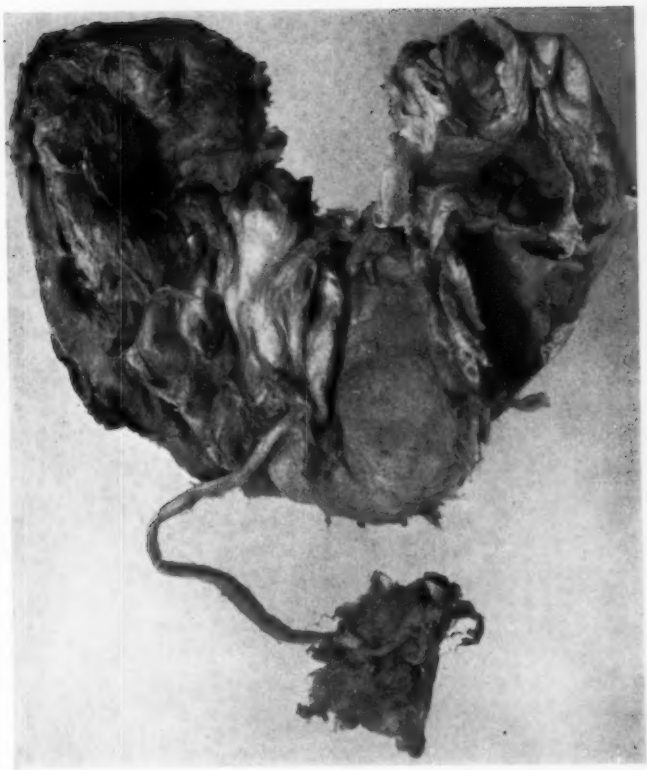


Half of double kidney and ureter. Removed at operation for stricture of ureter.

FIG. 13.

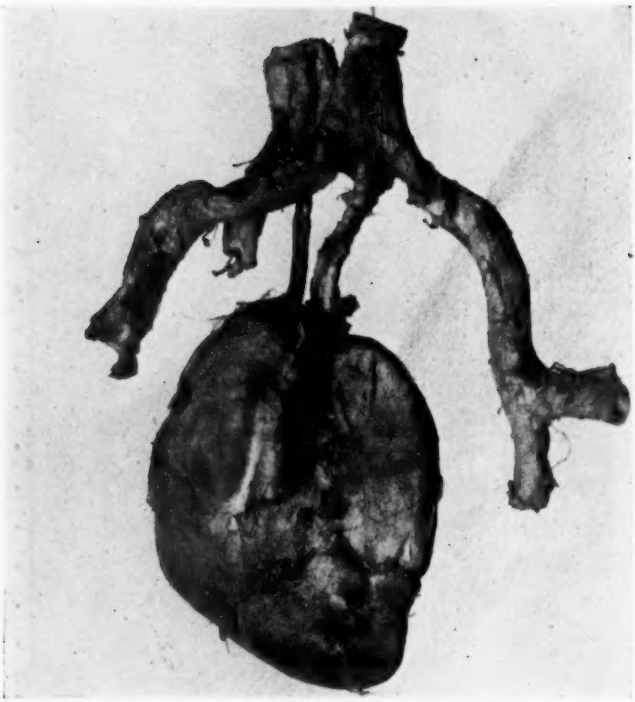
Half of horse-shoe kidney. Removed at operation for hydronephrosis.

FIG. 14.



Note division of ureter into three parts at site where the renal pelvis should have been. (Autopsy specimen.)

FIG. 15.



Pelvic kidney, showing blood supply arising at juncture of iliacs and entering upper pole of kidney. (Autopsy specimen.)

tissue. Heavy renal tissue so placed undoubtedly gives symptoms if we can rightly interpret them.

Rovsing's [14] recently published cases of horseshoe kidney with operative verifications are very suggestive. In three cases the same symptomatology was noted, the predominant symptom being pain experienced in the abdomen and lumbar region and beneath the epigastrium. These pains generally radiate downward and usually manifest themselves while the patient is standing upright, being then almost continuous. They are mitigated greatly by rest and disappear completely after prolonged rest in bed. These patients suffer severely from continuous jarring and the suffering is increased by muscular effort, such as lifting. Throbbing and a sense of pressure in the abdomen may occur and upon bending backward their discomfort is greatly increased. From their situation such kidneys are more liable to injury, compression of the abdominal vessels may occur and a case of thrombosis of the iliac and femoral veins, causing œdema of the legs and ascites, as reported by Neufville.[15]

In the diagnosis of horseshoe kidney the associated anomalies of the genital system are to be considered as they are developed together. Such conditions are frequently noted with congenital kryptorchidism, hypospadias, atresia of the anus, double or bicornate uterus, absence of vagina, etc. Such cases have been reported by Tillmanns,[16] Gerster,[17] and others.

In spite of the fact that there are sufficient data on this subject to permit of a diagnosis, it will not as a rule be made before operation except in the minority of cases until the subject is kept more in mind by the diagnostician. Most of the cases reported are accidental findings in the course of operations on the kidney or other abdominal organs, or are contained in postmortem reports. In a number of instances, horseshoe, irregular or gross single kidneys have been removed from the body before a diagnosis was made. We have at our disposal then the physical examination and, as Braasch [18] points out, in addition to the cystoscope and radiograph the great assistance obtained by pyelography with colloidal silver

injections. The latter are more accurate than the opaque ureteral catheter, especially in establishing the diagnosis of multiple ureters and pelves. In horseshoe kidney and irregular varieties of double kidney of a congenital type, in the congenital single kidney (more rare than horseshoe kidney) and in the single kidney with atrophy or destruction of the other through disease we have conditions which tax the diagnostic ability of the surgeon to the utmost. The lesson we must learn then in every case in which we are not positive of the condition, is always to explore the other kidney, usually through a separate incision, before removal of a tumor or a diseased kidney, and in abdominal surgery in which tumors of unknown type and origin are discovered, regardless of location, the kidneys should be palpated before the removal of the tumor.

Operation.—In some instances the incision will be a transperitoneal one. The lateral incision described by W. J. Mayo[19] will suffice in most cases. It is as follows:

"Beginning at a point two to two and one-half inches lateral to the dorsal spines near the outer margin of the erector spinæ muscle, a longitudinal incision is made two or three inches in length through the skin, superficial fascia and posterior layer of the lumbodorsal fascia (vertebral aponeurosis) which covers the erector spinæ muscle. The incision lies behind the twelfth rib from the angle, if present, nearly to the head, and reaches downward to a point one-half inch below the angle. From this point the incision passes obliquely downward and forward along the anterior margin of the quadratus lumborum muscle to a point an inch above the crest of the ilium, and there turning runs forward parallel to the iliac crest as far as necessary.

"The posterior superior lumbar triangle (Kelly) just beneath the twelfth rib is then exposed by cutting an opening through the external and internal oblique, transversalis, and latissimus dorsi muscles, exposing the transversalis fascia in its lumbar portion. This fascia is then opened freely, exposing the perirenal fat. The ilio-inguinal and iliohypogastric nerves are identified and retracted out of harm's

way and the lower part of the incision completed. The twelfth rib is then cleared in its posterior portion upward and backward nearly to the articulation of the rib with the transverse process of the twelfth dorsal vertebra, and the pleura pushed upward. By retracting the erector spinæ muscle on the one hand and the costal margin on the other, a wide exposure is accomplished at the point of previous inaccessibility. As a rule the kidney can readily be drawn through the incision to the surface with but little traction. The incision is easily closed and there is little or no danger of hernia."

As these cases will often be discovered during operation on the kidney the possibility of horseshoe kidney must be considered when it is unusually difficult to deliver the lower pole. This occurred in my last case, one of pyonephrosis of half of the horseshoe kidney. The renal tissue nearly the full size of the normal kidney passed in front of the large vessels. After examination of the blood supply, which is so frequently abnormal in such cases, this tissue was divided and sutured with catgut. In a case that was not pathologic other than the abnormality, Rovsing relieved the pain and general symptoms by division of the isthmus.

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THE EMBRYOGENETIC RELATIONSHIPS OF TUMORS OF THE KIDNEY, SUPRARENAL, AND TESTICLE.*

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INTRODUCTION.

THE urinogenital system presents more gross and microscopic anomalies than any other set of organs in the human body. This is because nature in the development of these organs pursues an indirect and wavering course. Nowhere else in the body are organs in the embryo first developed to a stage in which, like the mesonephros or Wolffian body, they present all appearance of being capable of active function, then only to degenerate and have their remains utilized for the building of new structures as the permanent kidney and testis. It is only by a study of the details of the intricate combinations and recombinations of the primitive factors which are used in the making of the urinogenital system that we shall come to understand in the adult either the gross surgical anomalies or those more obscure aberrations which appear to contain the explanation of the puzzling tumors of the kidney and testis. The busy surgeon and the engrossed pathologist are both apt to overlook the enormous amount of accurate detailed observation which is being made by embryologists on the development of the urinogenital system. The last decade has seen an almost complete revolution in our ideas of the essential embryology of the system and there are yet many obscure points which would appear to have a direct bearing upon its pathology. I wish herein to call attention to the chain of relations, to which new links have recently been

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added, between the development of the organs in question and their pathology.

Huntington's[4] Harvey lecture of 1907 gave such an excellent summary of the gross anomalies of the genito-urinary tract that it is unnecessary to again cover the field. I shall therefore confine myself to a consideration of the more minute embryologic anomalies which concern the development of tumors, based on a study of the operative and autopsy material from the Mayo clinic and consisting of the following: renal tumors, 92; adrenal tumors, 3; testicular tumors, 21.

This material has been supplemented also by a study of the human and comparative embryology of the regions under discussion.

RENAL TUMORS.

In considering the embryologic relationships of the renal tumors, one groups them most conveniently into (*a*) tumors of the pelvis and collecting tubules, (*b*) tumors of the cortex, and (*c*) tumors of the capsule.

(*a*) *Tumors of the Renal Pelvis.* Most of the tumors of the renal pelvis—papillomas and carcinomas—apparently arise secondarily to chronic irritative processes of the pelvic epithelium and have no embryologic significance. Our series contains three pelvic papillomas, all of the angiocystic type, developing in the collecting tubules in the apices of the Malphigian pyramids. The four renal carcinomas in our series have taken their origin similarly in the collecting tubules, and two of these are demonstrably superimposed on extensive renal calculus formation.

There is, however, one tumor of the renal pelvis in our series which is apparently of embryogenetic origin. This is a squamous-celled epithelioma resembling histologically a cancer of the lip and evidently derived from the ectoderm. The explanation of the presence of ectoderm within the renal pelvis in this case is as follows:

The renal pelvis with its collecting tubules develops from the primary excretory or Wolffian duct. The primary ex-

cretory duct is initially the excretory duct of the pronephros. It is developed from the principal tubules of the pronephros which begin as evaginations of the mesoblastic parietal layer of each primitive segment stalk. It enters the cloaca low down on that structure at a point close to its rectal portion. Before the opening occurs, however, the lumen of the cloaca may be seen to evaginate into the blind end of the primary excretory duct. It will thus be seen that though the primary excretory duct is normally composed entirely of mesoblast, there is a possibility, as an abnormality, of ectodermal cells from the rectum being carried into its lower end by way of the cloacal wall. No other way appears by which one may account for the occasional though rare presence of these squamous-celled epithelial tumors within the renal pelvis.

(*b*) *Tumors of the Renal Cortex.* Occasionally a renal carcinoma, arising in the renal pelvis or collecting tubules, so involves the renal cortex that its pelvic origin cannot be positively determined. There are two such in our series. Occasionally also a renal sarcoma in the adult developing in a fibroma which has apparently had an inflammatory origin within the renal capsule may similarly so involve the renal cortex that its true point of origin is with difficulty made out. Much more rarely, I believe, do we have a primary spindle-celled sarcoma of the renal cortex arising from the adult connective tissue. There is but one of these of undoubted diagnosis in our series. This case is that of a girl sixteen years of age. As one reviews the literature, he is convinced that most of the renal tumors which have been diagnosed as sarcomas are in reality mesotheliomas or embryomas (Wilms's [3] tumors).

Our series contains two positively diagnosed and one doubtfully (exploratory operation) diagnosed embryomas or Wilms's tumors, one of these occurring in a child two years and the other two in children each five years of age. These tumors trace their embryologic relationship back to the formation of the nephrogenic cord, that portion of the mesothelium from the lower end of which is formed the secreting portion of the permanent kidney. In the very early embryo, the mesoderm forms a wedge-shaped plate on either side of the

medullary tube. This mesodermal plate early differentiates into three portions—a thick primitive segment (next the medullary tube), a constricted primitive segment stalk, and a thin lateral plate. The constricted primitive segment stalk furnishes the material from which the tubules of all three nephritic organs are developed. From the lateral plate are developed, among other things, muscle and cartilage. As the nephrogenic cord develops from the primitive segment stalk, it is in immediate apposition to the bases of the lateral plates, and it is perfectly possible for tissue from the lateral plate area to be included within the formation of the nephrogenic cord. This is especially true in the caudal portion of the nephrogenic cord, which here lies closer to the lateral plate than it does in its middle and cephalic portions. Now it is from the extreme caudal portion of the nephrogenic cord that the cortex of the permanent kidney is developed. Accordingly, we should expect to find here, if anywhere within the nephrogenic structures, inclusions of the lateral plate and subsequent developments therefrom of embryonic muscle, cartilage, etc. These are the structures which, along with other embryonic cells and tubules, give the diagnosis to the so-called mixed tumors of Wilms.

By far the most numerous tumors of the kidney are the mesotheliomas (so-called hypernephromas or Grawitzian tumors) of the renal cortex. I had the pleasure three years ago[12] of reporting before this society 32 cases of hypernephromas from the Mayo clinic. Since then, I have studied 22 more such cases from our clinic, making 54 in all, and tissues from 14 cases from the University of Minnesota clinic, or a total of 68 cases. Besides the 54 cases which have been diagnosed pathologically in our clinic, there are 17 cases which were diagnosed by the surgeon upon exploratory operation, making a total of 71 cases of mesothelioma out of a total of 92 renal tumors, or 78 per cent. of all tumors of the kidney removed.

Grawitz's[1] hypothesis of the derivation of these tumors from adrenal rests was based upon the following: (1) the tumors are situated immediately beneath the capsule of the

kidney; (2) their cells are different from those of the epithelium of the uriniferous tubules; (3) the cells contain fat which is normally absent from the renal epithelium but frequently present in the suprarenal epithelium; (4) the capsule of the tumor is similar to that which is found around suprarenal rests within the kidney but which are not changed into tumors; (5) the cells of the tumors are sometimes disposed in more or less regular cordons which resemble those of the suprarenal cortex.

Grawitz's hypothesis was accepted by most observers during the next quarter of a century following its formulation. During this time it was attacked by Sudeck [2] and finally quite effectively by Stœrck,[6] who showed that:

(1) The Grawitzian tumors most frequently develop at the lower pole of the kidney where adrenal rests are not found; (2) the so-called fat of the cells of the Grawitzian tumors is usually not fat but a vacuolation related to the glycogen content of the cells; (3) the Grawitzian tumor is a tumor of the renal cortex and not of the renal capsule in which adrenal rests are usually found; and that (4) though the Grawitzian tumors do frequently contain cordons, which, however, only remotely resemble those found in the suprarenal, yet they also almost invariably contain tubules, the analogues of which are never seen either in the normal suprarenal or in the tumors of that gland.

Stœrck's very convincing evidence and arguments against the Grawitzian hypothesis I have been able fully to support by a study of our own cases, as have also the observations of Jelle,[7] Trotter,[8] Zehbe,[10] Sisson,[11] and Glynn.[15]

It has seemed to me from the first, however, that there are serious objections to Stœrck's suggestion that these neoplasmas arise from regenerating convoluting tubules in the atrophic kidney. After a careful study of the embryology of the kidney and of the histologic structure of 48 cases, I proposed three years ago [13] the hypothesis that these tumors are really derived from islands of nephrogenic tissue which have failed to become connected with the renal pelvis, through the collecting tubules, of the developing kidney.

It will be recalled that as the primitive renal pelvic bud—derived from the primitive excretory (Wolffian) duct—grows dorsally from its point of origin, it is surrounded by a cap of mesothelial tissue, the metanephrogenic cord, which is the caudal extremity of the mass of mesothelium from the forward end of which has been previously elaborated the Wolffian body. After the first two or three branchings of the renal pelvis, at each later subdivision for the elaboration of the collecting tubule system, this cap of nephrogenic tissue is separated into masses, one of which remains surrounding the terminus of each of the growing collecting tubules. In the later subdivision of the tubules, masses of the nephrogenic tissue are also left in the angles of the branching tubules. The nephrogenic cells of each of these small masses soon arrange themselves as an oval or spheroid about an excentrically placed point which soon becomes a cavity, thus making of the cell mass a small elongated ovoidal vesicle. This vesicle then becomes fused at its lesser extremity with the end of the collecting tubule. From the vesicle are normally formed the renal glomeruli, the convoluted tubules, the loop of Henle, and the uriniferous tubules up to the straight collecting portion which is derived from the primitive renal pelvic bud.

For a long time it has been considered that the failure of the nephrogenic vesicles to form a tubular connection with the collecting tubules is responsible for the condition of congenital cystic kidney. A study of the development of the nephrogenic vesicle, however, has convinced me that such a failure in its embryonic development is responsible for much more than the formation of renal cysts. Primarily, the nephrogenic cap consists of somewhat darkly staining, round, and irregularly arranged embryonic cells. In the first stage of the formation of the vesicle, it is a solid mass of cells which is frequently somewhat elongated and presenting a cordon-like appearance. In its second stage it is first an ovoidal vesicle and then a tubule. Now all these embryonic pictures closely resemble those which we find making up the histologic elements of the Grawitzian tumors. I have therefore urged the hypothesis that these tumors are mesotheliomas, or more definitely neph-

romas; that is that they are elaborated from masses of nephrogenic tissue which have never become connected with the renal pelvis and which have never attained adult type in either form or function. In fact, I feel sure that as the evidence continues to accumulate, it will show first that the so-called Grawitzian tumors have nothing whatever to do with a suprarenal origin, and second that they are true mesotheliomas (nephromas) arising from masses of nephrogenic tissue, the normal embryologic development of which has been arrested or perverted *after* the beginning of the development of the kidney proper.

(*c*) *Tumors of the Renal Capsule.* That the renal capsule is not infrequently the site of tumors forming in its adult tissue is well demonstrated. Fibromas and in their wake spindle-celled sarcomas are not rare. Our series contains one of the former and two of the latter type, all arising in adults beyond 35 years of age. These sarcomas of the renal capsule are apt to invade the renal cortex and be mistaken for tumors arising in this portion of the organ.

As far as its embryologic relationships are concerned, the renal capsule is frequently the site of inclusions from the mesonephros, Wolffian body, and occasionally, though rarely, of inclusions from the suprarenal. The beginnings of the renal capsule are seen as embryologic connective tissue concentrically arranged about the embryonic kidney as early as in 13 mm. embryos, though the actual capsule, well differentiated from the surrounding tissue, is not observed until we reach 70 mm. embryos. In the early stages of capsular development, the degenerating tubules of the Wolffian body lie in immediate apposition to, or indeed commingled with, the embryonic connective-tissue fibres which enter into the formation of the capsule. Consequently the inclusion of masses of the degenerating Wolffian tubules in the renal cortex is very easily understood. We have in our series one well-marked case of this type, that is, an encapsulated mass of Wolffian tissue lying within the renal cortex.

Though it is true that undoubted inclusions of suprarenal tissue have been found in the renal cortex, I am convinced

FIG. 1.

(Case A 75112.) Prickle-celled epithelioma of renal pelvis.

FIG. 2.

(Case 15845.) Embryoma of kidney from child two years of age.

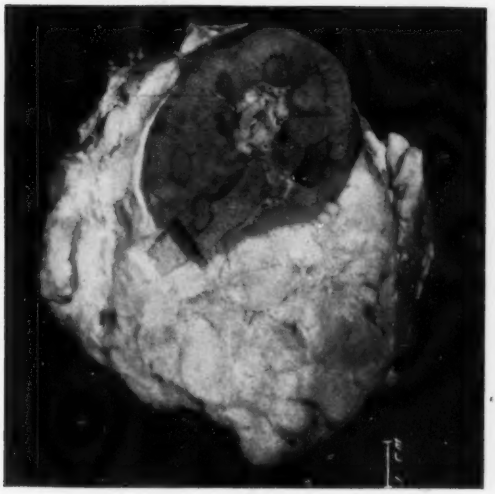
FIG. 3.

(Case 64508.) Mesothelioma of upper pole of kidney.

FIG. 4.

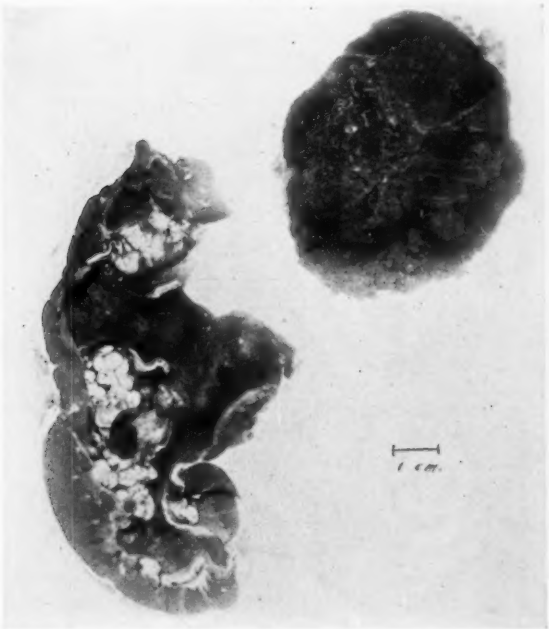
(Case 60651.) Mesothelioma of lower pole of kidney.

FIG. 5.



(Case A 73091.) Transverse section of kidney with spindle-celled sarcoma arising in capsule.

FIG. 6.

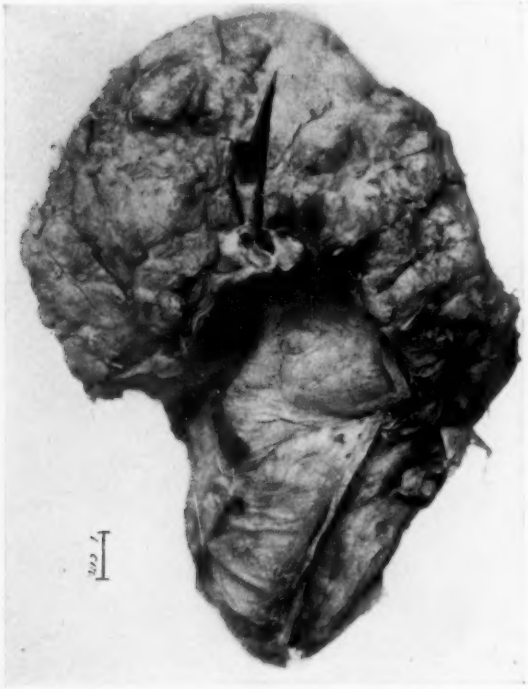


(Case A 66865.) Adenoma of suprarenal. Longitudinal section of kidney and tumor.

FIG. 7.

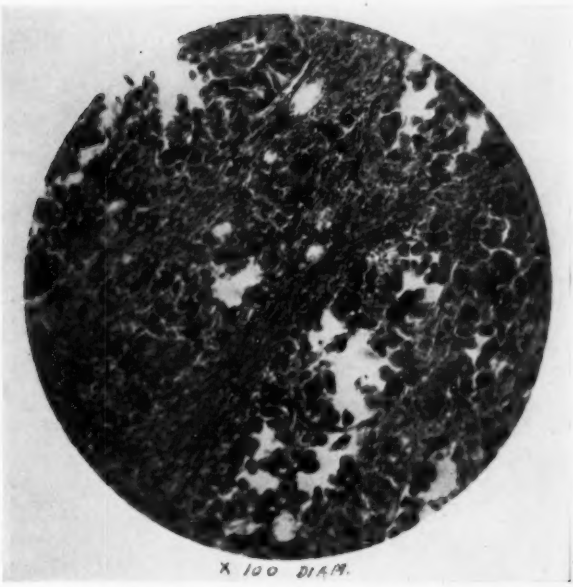
(Case A 66865.) Adenoma of suprarenal. Photomicrograph, × 100 diam.

FIG. 8.



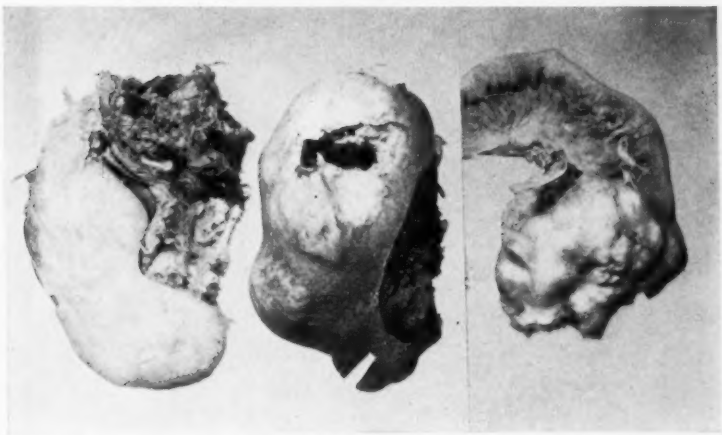
(Case A 72057.) Hypernephroma of adrenal.

FIG. 9.



(Case A 72057.) Hypernephroma of adrenal. Photomicrograph, × 100 diam.

FIG. 10.

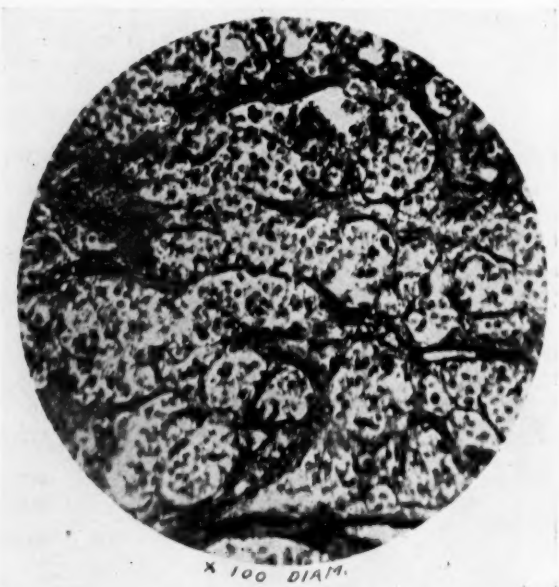


Case A 75198.) Hypernephroma of adrenal, with metastases to spleen and ileum.

FIG. 11.

(Case A 75198.) Hypernephroma of adrenal cortex. Photomicrograph, × 100 diam.

FIG. 12.



(Case A 39407.) Teratoma ("alveolar carcinoma") of testicle. Photomicrograph, × 100 diam.

that they are much more rare than they are usually supposed to be. Several pathologists with an extensive post-mortem experience state specifically that they have never personally observed a single instance. Glynn [15] in a recent careful survey of the literature has collected 17 cases, to which he adds two cases of his own. To these we may add one case from our autopsy records. They are usually well encapsulated, though at least one instance has been reported in which there was no visible connective tissue between the mass and the kidney structure.

Glynn notes the following facts opposed to the hypothesis that adrenal hypernephromas arise from the remnants of adrenal cortex:

(*a*) The histologic dissimilarity between tumors of the renal and adrenal glands.

(*b*) Renal tumors never influence growth of sexual characteristics.

(*c*) Why should adrenal rests, though comparatively rare in the kidney, produce hypernephroma, the commonest renal tumor, while adrenal rests in other localities, though comparatively common, so rarely produce tumors, either benign or malignant?

While it is perfectly conceivable that such masses within the renal cortex may form malignant neoplasms, I find neither in the literature nor in my own experience any evidence that such is the case. Should such tumors form, they must, to satisfy the present demands of diagnosis, conform to the histologic type of those tumors which we know to be primary in the suprarenal. In other words, it is but fair to assume that a neoplasm derived from wandering suprarenal cells will present the same histologic elements as neoplasms derived from suprarenal tissue in its normal position.

TUMORS OF THE ADRENAL GLAND.

The well-known fact that the cortex and medulla of the suprarenal are derived from different embryologic structures accounts for the great diversity of tumors of this gland.

The medulla is chromaffin tissue derived from the sympathetic nervous system and the cortex is derived from the cœlomic epithelium. Glynn [15] has recently reviewed the pathology of the rests and tumors of the adrenal cortex. His summary and conclusions in part are as follows:

"1. Tumors (of the adrenal) are rare, especially primary malignant tumors, which are represented by (*a*) round-celled sarcoma and (*b*) adrenal hypernephroma; an epithelial growth of cortical origin."

"2. Adrenal hypernephromas are associated with sex abnormalities almost invariably in children, usually in adult females before the menopause, but apparently never in adult females after the menopause, or in adult males."

A recent study of three tumors of the suprarenal which have come to our clinic adds additional evidence to the above. The first of these tumors of the suprarenal was in a woman (Case A6685) 41 years of age, who for 14 years had had hæmaturia at irregular intervals with pain in the right kidney, accompanied recently by dysmenorrhœa and considerable loss of weight. A clinical diagnosis of hæmaturia from chronic infection of the renal pelvis was made. At operation, the right kidney was found with a very thin cortex and a distended pelvis the seat of chronic inflammation and giving abundant evidence of the hæmaturia. An encapsulated tumor as large as a hen's egg was found above the kidney but pressing somewhat upon the ureter. Histologic examination of this tumor shows it to be an adenoma of the adrenal cortex.

The second case was a man 47 years of age, who, like two cases quoted by Glynn, had been noted for years for his enormous strength. He had been perfectly well until three months before the examination, when, after great exposure on a five days' tramp through slush and snow in Alaska, he developed pain and a tumor mass in the epigastrium. When brought to the clinic, there were multiple tumor growths over his trunk, head, and neck. One of these from the axilla was excised and on histologic examination a tentative diagnosis of hypernephroma was made. The disease steadily progressed and the patient died four months after the onset of symptoms. Autopsy revealed large tumors occupying the position of each suprarenal. There were small

metastatic nodules in each kidney, many large ones in the omentum, in the spleen, in the liver, in the heart wall, in the lungs, and in the lymphatics generally throughout the body. A careful histologic study of this tumor shows it to be composed almost entirely of large polyhedral cells with some multinucleated giant forms and a few smaller round cells, a typical hypernephroma of the adrenal cortex.

The third case was a man 68 years of age who had had "stomach trouble" for four months. Surgical exploration revealed numerous small tumors of the peritoneal glands and small intestine. The patient died four days later of pulmonary embolism. Autopsy revealed large necrotic tumors completely involving both suprarenals with metastases to the peritoneal glands, small intestine, spleen, and liver. Microscopically, the tumors are large, round and polyhedral-celled hypernephromas of the adrenal cortex.

These three hypernephromas of the adrenal cortex form an interesting series for comparison with the so-called hypernephromas of the renal cortex. The first case still recognizedly preserves the cordon structure of the adrenal cortex, and yet one would not hesitate to differentiate it from the cordons found in renal tumors. The two latter cases, which were far advanced and are parallel in their stage of development with most of the renal tumors in our series, have lost almost entirely all evidence of cordons. Their cellular structure, however, could not by any possibility be mistaken for any of the pictures found in our series of renal tumors. It is also especially interesting to note that the fat content of the cells of the adrenal tumors is very high, not only in the primary tumor but also in the metastases, including those in the kidney itself. This is in marked contrast to the almost if not entire absence of fat in the cells of renal tumors.

While these adrenal hypernephromas are of particular interest to the clinician in the light which they throw on the functions of the adrenal in relation to sex development, they are of quite as great interest in the negative evidence which they supply concerning Grawitz's hypothesis of the suprarenal origin of renal tumors.

TUMORS OF THE TESTICLE.

Ewing's [14] article on tumors of the testis two years ago has left little room for discussion unless based on evidence furnished by new material. In brief Ewing concludes:

"(1) Pure fibromas and pure leiomyomas of the testis exist but are extremely rare, as is also adenoma occurring in atrophic undescended testes."

"(2) Primary lymphosarcoma and pure spindle-celled sarcoma are of uncertain origin."

"(3) Chondroma, myxoma, lipoma, rhabdomyoma, and carcinoma have not been shown to exist apart from a teratomatous origin."

"(4) Alveolar large round-celled perivascular and other forms of so-called sarcoma testis are of epithelial and teratomatous origin."

"(5) The commonest tumor of the testis is an embryonal carcinoma, alveolar or diffuse with polyhedral or rounded cells and often with lymphoid stroma. These tumors are probably one-sided developments of teratomas."

"(6) Teratoma testes arise from sex cells in the neighborhood of the rete whose normal development into spermatogonia has been suppressed but whose potencies remain intact and ready to express themselves in the various forms of simple or complex teratomas."

Our series of tumors of the testicle contains 21 cases, two of which were exploratory only, each apparently a sarcoma of an undescended testicle. The histology of the other 19 cases has been studied in detail. Though the specimens vary a great deal in their relative cell content, every one of them would undoubtedly be classed as a teratoma by Ewing. Eleven of the 19 are alveolar embryonal carcinomas with rounded or polyhedral cells, 5 show cartilaginous and 7 myxomatous tissue with their structure. From a clinical stand-point it is somewhat interesting to note that 6 of the 19 cases give a history of injury definitely related to the onset of symptoms in the injured testicle.

Ewing's hypothesis is that these teratomas of the testicle arise from sex cells whose normal development has been suppressed. This is interesting in relation to the recently published observations of Felix [16] on the presence of wandering genital cells in early human embryos. Felix has found in a careful search of all of the tissue in a human embryo of 2.6

mm. (13 pairs of primitive segments) 7 genital cells, all in the immediate vicinity of the cloaca and all between it and the visceral mesoblast. In an embryo of 2.5 mm. (23 primitive segments), he found 12 primary genital cells in the same locality. Felix observes that "if these wandering genital cells are strays, they perhaps do not degenerate but may further develop, and above all divide, forming parent cells for tumors and especially for teratomas."

The genital cells are the most important cells of the reproductive glands. Until recently embryologists described their derivation from the cœlom. Recently, however, much evidence has been accumulating to show that their origin is directly from the segmentation of the ovum and it is possible that the future sex of all the genital cells is already determined at fertilization. Whether these genital cells differentiate into spermatogonia or oögonia is still unsettled. On the other hand, it is readily determined that the indifferent reproductive gland does change into testis or ovary as the case may be. In the male, this change is clearly shown in 13 mm. embryos. It consists of the appearance of anastomosing epithelial cords and the development of the tunica vaginalis between these cords and the surface epithelium. The testis cords are initially composed of indifferent epithelial cells with darkly staining nuclei. The genitaloid cells lie irregularly between these. They are found present at the time of the earliest appearance of the cords. Some of the genitaloid cells by the time the embryo has reached 70 mm. in length have developed into genital cells. Branca and Bresseta [5] have shown that, while the number of genital cells in the testicle increases up to birth, after birth they entirely disappear and the tubules of the testis contain indifferent cells only. At puberty a new growth of genital cells is developed and from these are formed the spermatozoa. Popoff [9] has confirmed these observations, which would seem to have an important bearing upon Ewing's hypothesis of the formation of testicular teratomas from genitaloid cells. This wide gap between the genitaloid cells of the embryo and those which form at puberty may account for the great variation in type and speed of development of the teratomas of the testicle.

Summary.

RENAL TUMORS.

1. Of 92 renal tumors studied, there were 3 pelvic papillomas, 4 carcinomas, 1 squamous-celled epithelioma, 1 adenoma, 1 fibroma, 7 sarcomas, 1 Wolffian tumor, 3 embryomas (Wilms's tumors), and 71 mesotheliomas.

2. The renal papillomas and carcinomas apparently arise secondarily to chronic irritative processes of the adult pelvic epithelium.

3. The rare squamous-celled epithelioma probably is a neoplastic development from the embryonic inclusion within the renal pelvis of ectoderm which has found its way into the lower end of the primitive excretory duct by way of the cloaca.

4. The embryomas of the renal cortex composed of renal and other tissues and occurring in young children are, according to Wilms, derived from inclusions of the lateral embryonic plate within the caudal portion of the nephrogenic cord in the early embryo.

5. The most numerous tumors of the renal cortex, the so-called hypernephromas or Grawitzian tumors, are apparently mesotheliomas derived from nephrogenic vesicles which have failed in the early embryo to form a tubular connection with the renal pelvis.

6. Most of the few true sarcomas of the kidney develop primarily in adult tissue of the renal capsule and involve the cortex secondarily.

7. The renal cortex is also frequently the site of inclusions from the mesonephros and rarely of inclusions from the suprarenal gland. Rarely if ever do either of these inclusions in the renal cortex form malignant tumors.

ADRENAL TUMORS.

8. Of the three primary tumors of the adrenal studied, one was an adenoma and the other two hypernephromas of the adrenal cortex.

9. Primary malignant tumors of the adrenal are either round-celled sarcomas or more frequently hypernephromas arising from the adrenal cortex.

10. Adrenal hypernephromas frequently induce abnormalities of sex and strength.

11. Tumors of the adrenal, in whatever stage of their development, bear no histological resemblance to most mesotheliomas (so-called renal hypernephromas).

TESTICULAR TUMORS.

12. Of the 21 tumors of the testicle, all of the 19 which it was possible to study in histologic detail were teratomas.

13. So far as can be determined, the history and histology of these 19 cases are in harmony with Ewing's hypothesis that teratomas of the testicle arise from sex cells whose normal development has been suppressed.

14. The difference in time of development of the embryonic crop of genitaloid cells and the next generation which appears at puberty may account for variations in structure and *tempo* of the testicular teratomas.

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EXCISION AND SUTURE IN THE TREATMENT OF DENSE, CLOSE, URETHRAL STRICTURES.

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THE majority of strictures of the urethra yield to simple dilatation or dilatation following internal urethrotomy, but the same cannot be said of the traumatic variety. Of the various types of trauma, urethral rupture is by far the most important, particularly when the lesion is seated in the bulbo-perineal region, because here the solution of continuity is the most extensive. A number of most important signs accompany these ruptures, being usually early in appearance and unique, while those arising in the inflammatory type are multiple and slow in development. The traumatic stricture is to the feel like a callus in the urethral wall, and as it is very retractile there is a marked tendency to tight stenosis, from which a serious ultimate condition of affairs ensues.

In cases of impassable stricture an imperative interference is required, as the patient either presents complete retention or micturates by overflow. Puncture of the bladder, which is inoffensive, may be resorted to, but this merely is an expedient for temporary relief, and since both external and internal urethrotomy is generally a failure, resection of the stenosis, followed by end-to-end suture of the canal, with temporary deviation of the urine is the only truly effective surgical method for completely and permanently restoring the calibre of the canal.

As to the utility of resection, opinion is unanimous, but the same cannot be said of reconstruction of the urethra. Once the resection done, the choice is offered between secondary union, immediate end-to-end suture, simple urethrostomy, and, lastly, urethrorrhaphy with deviation of the urine.

Secondary union without sutures with a permanent catheter in the bladder has given unsatisfactory results, and it is quite safe to assume that a complete recovery never occurs. The end-to-end suture does not always give favorable ulti-

mate results, although the immediate results may be good with an apparent union by first intention. But primary union is very difficult to obtain, and a slight infiltration often takes place around the temporary catheter, so that not infrequently some sutures must be removed. Now, whenever secondary infiltration occurs around a suture, it is practically certain that a new callus will develop around the canal, so that it is a matter of impossibility to obtain perfect results. After a time these patients return with diminished calibre and symptoms of stenosis.

Generally speaking, these two operations obligate the use of the permanent catheter during the process of repair, and if in some fortunate instances this procedure does not appear to present inconveniences, nevertheless often a seropurulent oozing appears in the wound on the second or third day and a few days later the wound finally disunites to a certain extent, so that primary union has failed. And even if primary union does not fail after circular urethrorrhaphy has been done, a new stenosis will ultimately arise. I believe that the temporary catheter is to blame, as its various manners of detrimental action are readily understood. In the first place it is a foreign body and like all these, even when aseptic, it is bound to set up an irritative process beginning as in a serous exudate which is not long in becoming purulent if the urethra is only mildly infected. Even in the case of a virgin urethra, the saprophytes of the canal easily develop as in a culture tube in the secretions enclosed between the catheter and urethral walls. The evident result is that union by first intention is seriously compromised.

The permanent catheter is used to isolate the urine from the urethra, and in spite of appearances this *desideratum* is not realized and this for many evident reasons, such as occlusion of the catheter, faulty introduction of the instrument, and simple capillarity. If the eye of the instrument becomes occluded with mucus or clot, the urine must of necessity flow along the walls and thus come in contact with the sutures. Then, in spite of every care in properly placing the catheter, it is next to impossible to prevent a trifling amount of urine from stagnating in the neck of the bladder before it reaches

the eye of the instrument. This stagnating urine will find its way out along the outside of the instrument, either from simple capillary action or from contraction of the bladder, and what is far more serious, this urine will be retained at the level of the sutures for the very good reason that at this point the canal hugs the catheter tightly on account of the sutures.

All this goes to prove that the use of the permanent catheter is particularly serious, because it results in preventing primary union. Orchitis from the use of the instrument is frequent, so much so that it is hardly necessary to refer to it. For these reasons I feel that the employment of the permanent catheter should be discarded in the cases under discussion.

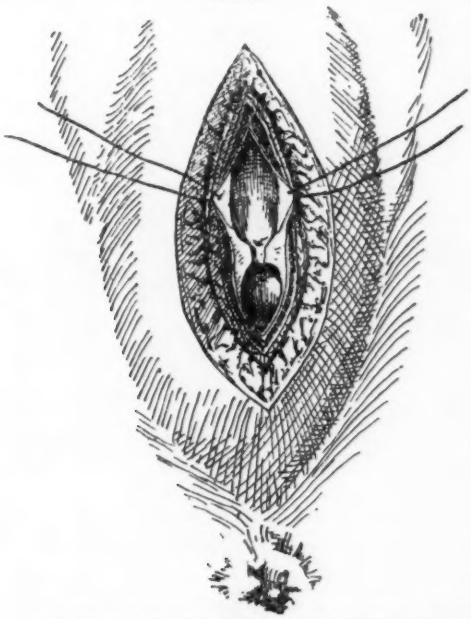
Urethrostomy is a temporary gun-barrel suturing of the two ends of the urethra to the perineum after rupture or operative wound of the canal, and has been resorted to by those operators who have found that immediate end-to-end suture was unsatisfactory or even disastrous on account of the permanent catheter. Another indication for this procedure is the too considerable separation of the two ends of the canal resulting from an extensive resection so that the tension after end-to-end anastomosis would compromise the operative results. But this reason has lost much of its value, because, contrary to what is present in traumatic ruptures, in stricture there is usually a distinctly defined and limited hard area. And even in instances of extensive external urethrotomy, one can dissect a good amount of the anterior end of the urethra, quite enough in extent to be able to easily bring it into approximation with the posterior end. It is evident that urethrostomy necessitates a second interference two or three months later in order to close the perineal meatus and reconstruct the canal. At present some operators are resorting to this technic in cases of traumatic rupture successfully, but the operation is complicated and necessitates two séances and, excepting the very fortunate cases, the results *à priori* should not be favorable for the maintenance of the calibre of the urethral canal.

We now come to the procedure of choice, in the writer's opinion, for the treatment of traumatic or inflammatory strictures when the latter present analogous conditions.

By it a "radical cure" can be obtained and the ultimate results are excellent when the technique is properly carried out.

The operation comprises four steps, namely, opening the canal, resection of the stricture, repair of the continuity of the urethra, and, lastly, deviation of the urine. If the stricture is passable a Syme's conductor, on which a conducting bougie is screwed, is very useful, but if the stenosis is impassable the tip of the conductor is pushed in contact with it so as to en-

FIG. 1.



Guide sutures inserted and stricture exposed.

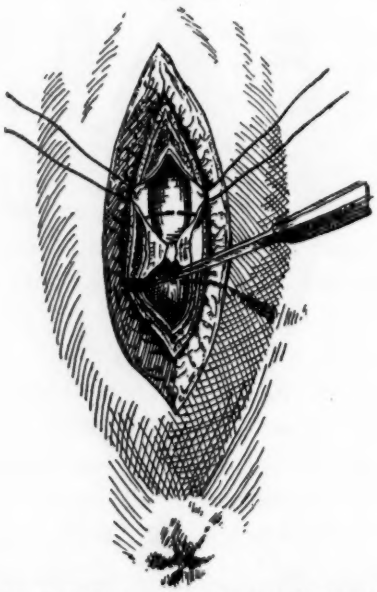
able the operator to recognize the anterior segment of the canal, likewise the anterior limits of the stricture, and by steadying the penis makes the excision easier. If, in spite of this, the posterior end of the urethra cannot be found so that retrograde catheterization is required, the manner of deviation will differ.

With the patient in the lithotomy position a large sound is introduced and held by an assistant in such a way that it causes the skin of the perineum to bulge over the convexity of the instrument. An incision is carried from the base of the scrotum to within two centimetres from the anus. The main

point is to remain in the median line, so as not to become lost in the periurethral sclerous tissue.

If the sound cannot be passed through the stenosis it is introduced as far as the stricture, and the urethra is incised on the tip of the instrument. A guide suture is then inserted in each border of the urethral incision, and an attempt is made with a stylet to discover the posterior opening of the canal (Fig. 1). If in spite of careful endeavors the posterior end cannot be found, retrograde catheterization must be done.

FIG. 2.



Excision of stricture commencing at posterior portion.

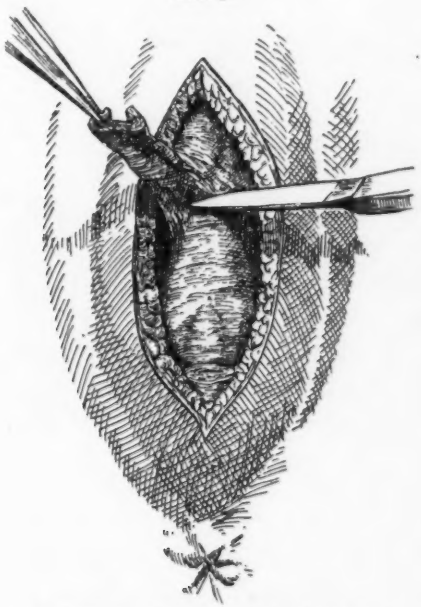
Both ends having been found, all the sclerotic tissue surrounding the canal is removed with scissors, particular care being given to cleaning the region and obtaining a clean cut section of the anterior and posterior ends of the canal (Fig. 2). As much as six centimetres of the urethra can be removed without danger, but a large amount will make the reconstruction a delicate affair which will probably result in failure. The hemorrhage occurring is of little consequence, but any spurter should be temporarily caught in clips.

When the resection has been accomplished, the posterior

part of the urethra is to be dissected out to a short extent, not more than one or two centimetres, while the anterior end is, on the contrary, freed to from three to five centimetres, according to the amount of urethra resected (Fig. 3). It is of absolute necessity that the two ends shall come in contact easily without much traction being required.

After the urethra has been sufficiently freed all bleeding vessels should be ligated excepting those of the urethra, which will be controlled by the sutures.

FIG. 3.



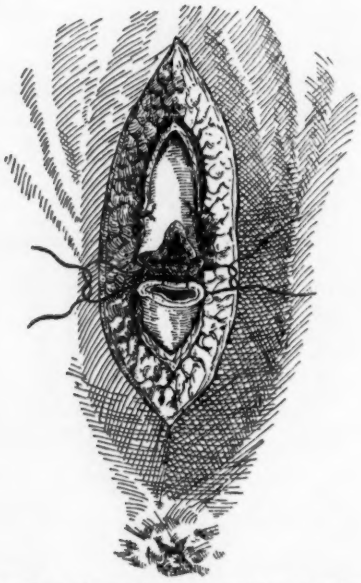
Excision of strictured portion of urethra.

Before inserting the sutures into the urethra it is important to first place some supporting sutures which allow the two ends of the urethra being approximated without any traction on the sutures. The anterior end of the urethra is drawn down and then a catgut suture is inserted on each side in the periurethral tissues (Fig. 4), and when these are tied the posterior and anterior ends of the canal will be brought into contact without any effort.

Begin by placing two fine catgut sutures in the anterior

portion of the urethra without including the mucosa and then through the posterior end. A large sound is now passed into the bladder and the two sutures are tied. The remaining sutures are then inserted with the sound in place and thus it will be seen that all knots are outside the canal. A large sound is essential because the moulding of the canal is made around it and it is of importance to have the dimensions as large as possible.

FIG. 4.



Approximation of the ends of the urethra after excision of stricture, showing method of suturing.

The introduction of the sound from the anterior to the posterior end is rather delicate, and an angular instrument is to be preferred for this reason. If both ends are nicely approximated the passage of the instrument will sometimes be easy, but I prefer to pass it before the two preliminary urethral sutures are tied, because it can be directly inserted into the posterior end under the direction of the eye. The remaining sutures are then inserted and tied. Two or three fine superficial urethral sutures may then be inserted to give additional support.

The posterior end of the urethra having been exposed by dissection to the extent of at least one centimetre and a half

behind the point of suture, the bulbous portion is incised longitudinally for about two centimetres. The knife should be directed forward and upward and should progress toward the pubis so as to come in contact with the sound, which serves as a guide. When the urethra has been reached a buttonhole one centimetre long is made in it and the borders seized with clips; the sound is then withdrawn and a catheter is passed into the bladder through the buttonhole (Fig. 5). When its correct position has been ascertained it is held in place by two silkworm-gut sutures passed through the border of the cutaneous incision.

The operation is completed by approximation of the soft structures, but when resection of the perineum has been extensive on account of many fistulous tracts the approximation will not be complete. An opening must be left behind the catheter to allow drainage of the fluids from the wound. Therefore, the skin is only sutured over its anterior two-thirds and then a small drain is placed in the opening left in front of the deviation catheter.

Let us now consider briefly those cases where the posterior end of the urethra cannot be found after a careful search, which should never be too prolonged. Naturally, retrograde catheterization is to be resorted to, and under these circumstances the suprapubic opening in the bladder will be used for the deviation of the urine and the buttonhole in the urethra becomes unnecessary.

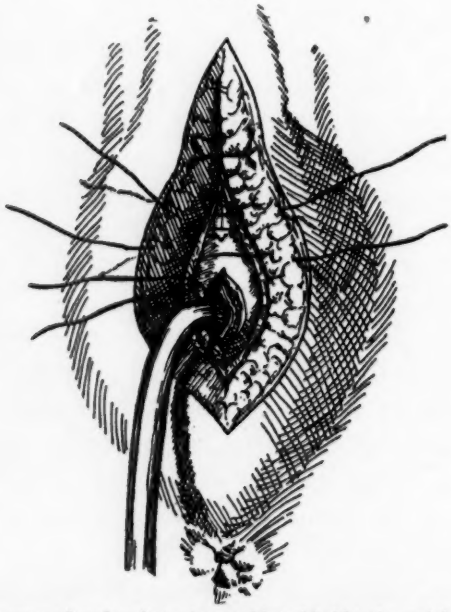
If, now, the stricture is located so far back that the deviation must be obtained either by a catheter placed in the lowest part of the wound, through the membranous urethra, or, after dissecting off the rectum through the prostatic urethra, it is the writer's opinion that suprapubic drainage is to be by all means preferred, as it avoids infection of the urethral wound from the catheter.

The care of the deviation catheter is of the utmost importance and its proper functionating must be carefully supervised. The bladder should be washed out daily through the catheter with a 1:2000 silver nitrate solution, but the anterior urethra should never be washed out, as it is an error to fear infection of the sutures from this source. Likewise no

instrument should be passed until the twelfth day, when cicatrization may be supposed to be complete.

The deviation catheter may be removed on the tenth day and the patient allowed to urinate *per urethram,* but the canal must not, I repeat, be interfered with instrumentally. Micturition will take place mostly through the buttonhole, but within forty-eight hours after the catheter has been removed the urine will be voided by the urethra, and the fistula will close in from five days to a week.

FIG. 5.



The urethra sutured and catheter inserted into bladder through buttonhole in bulbous portion.

If there is a severe cystitis present at the time of the operation, it is well to continue the deviation longer, in some cases three weeks or a month.

In closing, I would sum up by saying that suprapubic deviation is indicated in (1) impassable strictures requiring retrograde catheterization; (2) impassable strictures but seated far back, two centimetres in front of the membranous urethra. In all other cases deviation should be obtained by a urethral buttonhole as described.

OPERATIVE FIXATION AS A CAUSE OF DELAY IN UNION OF FRACTURES.*

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THE great activity, developed in recent years, in the operative treatment of closed fractures, makes it desirable to report any instances of operative fixation that have been followed by unsatisfying symptoms or disastrous results. Many of us have for years been opening recent, closed fractures for the discovery of complicating lesions, for operative reduction, or for satisfactory fixation. My own advocacy of such measures began about 1885. Hence I should not be considered an unduly prejudiced critic of the present furore for operative uncovering of the ordinarily severe closed fractures of the tubular or long bones.

It seems to me, however, that the earnest advocacy of such radical procedure by especially expert and experienced operators has a tendency to do harm to surgical science and to encourage the assumption of unnecessary risks by the public. The situation resembles that of the period when hundreds of women were unnecessarily rendered sterile by oöphorectomy for the so-called sclerotic ovary, others subjected to needless nephrorrhaphy for loose kidneys, and both sexes deprived of useful thyroid glands; because these operations were found to be comparatively free from fatal issue and because neither the docile patients nor the hasty surgeons knew the true physiological worth of the organs thus subjected to surgical insult. A similar illogical following of brilliant operative masters is now occurring in the domain of tonsillar pathology, and is fast approaching, one may fear, in the treatment of closed fractures of the bones of the extremities.

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* Read before the Philadelphia Academy of Surgery, Dec. 2, 1912.

Operative surgery has a brilliant career, but its activities must be controlled by a logical mind, not too much given to dwelling on the conservatism of the past or so flushed with victory that it encourages running amuck through hospital wards.

I recently reported [1] two deaths following fixation of closed fractures of the femoral shaft with plates and screws. Dr. Joseph Ransohoff,[2] of Cincinnati, says that Babler in a late report of the St. Louis City Hospital mentions two deaths occurring out of 13 cases of simple (closed) fractures of the femur treated by plating. He himself knows of two other deaths after operative treatment of this injury. I, myself, have heard of one death other than mine occurring in Philadelphia under similar circumstances. This shows that operative fixation of fractures of the femur at least is not as innocuous a proceeding as some medical men seem willing to assume.

My present purpose is to seek information on the comparative rapidity of bony consolidation of fractures under non-operative and operative treatment. It will be conceded at once that to obtain a mathematical determination of this question, it would be necessary to apply both methods to the same number of fractures of the same character and severity, occurring in the same part of the skeleton, and treated under the same circumstances by the same surgeon. These conditions are manifestly unobtainable. I must, therefore, be content to give the statements, which I have obtained from recent surgical literature, bearing on the length of time required for the union of broken bones under these dissimilar methods of treatment.

My attention was called to the possibility of plating being a cause of delay in union by having under my care a young man in whom this contingency seemed to take place.

Mr. D. S. B., aged twenty-nine years, sustained on April 13, 1912, a closed fracture of the right tibia, a little below the middle of its shaft, and a double fracture of the fibular shaft of the same

leg, which also was closed. The injuries were due to striking his leg against that of another player in a game of baseball. His general health was good. A surgeon endeavored to set the fractured leg without anæsthesia, but was not successful. Then 15 pounds extension, made with an anklet and a pulley, was employed for several days. Ten days after the receipt of injury, an X-ray picture was taken showing a fracture of the tibia, which was almost transverse, and two adjacent fractures of the fibula. At this time an attempt was made under chloroform anæsthesia to reduce the fragments. This was unsuccessful.

Fourteen days after the accident the tibia was exposed by a longitudinal incision under ether anæsthesia, and a Lane plate about four inches long was applied with screws to the fibular aspect of the tibia. The reduction of the fracture was perfect. No fixation apparatus was used for the fibular breaks. A gypsum encasement was put upon the leg for external support. It covered the ankle-joint. I do not know whether it went above the knee. The external wound healed by first intention and without pain. The gypsum splint was split two weeks after its application.

Ten weeks and two days after the receipt of the fracture (June 24, 1912) he came to me walking on crutches, and with the leg still protected with the gypsum splint. The fibula had apparently united, but there still was marked anteroposterior mobility at the seat of the fracture of the tibia. There was no swelling as of tibial callus on the subcutaneous surface of the shin bone; and the apposition of its fragments was perfect. I treated him with calcium carbonate, gr. v., and calcium lactophosphate, gr. v., internally three times daily before meals, used the rubber bandage around his thigh for congesting the seat of fracture, supported the broken bone with a gypsum encasement, and had him walk on crutches and stay a good deal in the open air. This line of treatment I continued for six weeks (until August 5, 1912) without producing any special effect on the ununited tibia. He was quite anxious about his useless leg, but seemed in good health except for this worry. He was a rather free user of tobacco.

As sixteen weeks and two days had by this time elapsed without union of the major bone occurring, I advised removal of the Lane plate and inspection of the site of fracture. I ex-

pected to find muscle or fascia between the ends of the fragments, or that the tibia was held apart at the break by the plate or by the already united companion bone. My suggestion to the patient was that I would remove the plate and then perhaps refracture the fibula to gain close contact of the tibial fragments or insert a bone graft cut from the crest of the same tibia in the gap between its fragments.

The tibia was exposed by an incision in the old scar, the plate was found hidden, under fibrous tissue and a small boss of callus, on the fibular aspect of the tibia. The subcutaneous or inner surface of the tibia was smooth, showing no deformity and no elevation of callus under the periosteum where the line of fracture was situated. The screws were imbedded in the bone, but were readily removed. There was no pus about the plate or screws. There was, however, a slight darkening of the tissues and some softening of the structures in a few places where they were in contact with the metal. The plate was removed, as were all the screws. A few drill punctures were made into the bone ends and into the tissue between them. The wound was closed without drainage, and it healed promptly.

The leg was dressed with a gypsum encasement and in a few days the man was allowed to be up on crutches. The rubber bandage for engorging the limb was used for longer periods of the day than before, lime salts and tonics were given, he was sent to the seashore, and much was done to encourage him. His tobacco was limited.

When seen on November 30, 1912, which was exactly 33 weeks after the fracture occurred, he still had a slight antero-posterior movement of the tibia at the seat of the fracture. At this point there is a slight mound of callus, and the bone is nearly solid. The gypsum splint has been discarded for three weeks and he has not used the rubber bandage for a short time past. He still takes small doses of calcium carbonate and calcium lactophosphate. He uses a cane for walking outside his home, but in the house uses the leg without any support. He has been attending to his scholastic duties for about two months. He was ordered to wear the rubber bandage for an hour a day and to take a small amount of lime salts. He evidently soon will have firm and satisfactory cure of the fracture without deformity.

In looking for a cause of delayed union in this patient I came to the conclusion that it was not unlikely that the opening of the tissues to apply the fixation plate had something to do with the delay in solidification of the fracture of the larger bone. Slow union or non-union of a fracture from interposition of muscle or fascia is not unusual, but here my exploratory observation at the time I removed the plate showed that this was not the cause of the trouble in this instance. It is true that the patient was very much worried over his condition and was away from his family at the time the accident took place. He also was very anxious to obtain a rapid cure because of the necessary resumption of his teaching in the fall. All these facts have seemed to me scarcely a sufficient reason for the want of callus formation at the seat of the fracture of the tibia in a man so young and apparently so healthy. It is true that there were three fractures, the two in the fibula and the one in the tibia, to be united, the existence of which threw a little more responsibility upon the bone-making powers of the blood.

Upon looking over recent surgical literature, I have been struck with the number of surgeons who believe that the opening of a closed fracture, for the purpose of establishing an anatomical correction of a deformity, has a tendency, not to shorten but to lengthen the time of consolidation of the broken bone.

Some of the advocates of the operative treatment of fractures, and particularly, I think, Mr. Arbuthnot Lane, believe that opening the tissues to gain access to the seat of fracture does not delay the union of the broken bone. Mr. Lane, I think, states that anatomical reposition in the manner advocated by him is almost never followed by delayed union or non-union.

Dr. Thomas W. Huntington, of San Francisco, says that it is interesting to note that in practically all cases where anatomical reposition has been attempted, three things have been accomplished: rapid bony union, absence of deformity, and absence of pain.[3]

Huntington in another article printed in 1908 [4] in speaking of fractures of the femoral shaft states that approximate anatomical reposition is essential to quick repair and ideal result. He also believes that a very large percentage of all cases of delayed or non-union can be attributed to faulty adjustment. These two writers represent, I think, the opinion which most of us held when, within recent years, the unusual activity in operative treatment of these lesions began. That broken bones should unite by first intention when the fragments were properly adjusted seemed in accord with what happened in wounds of the soft parts and was, therefore, accepted. Perhaps due weight was not given to the possible physiological differences in the repair of tissue in which the deposition of inorganic salts is required to complete the restitution of physiological function. It is also possible that our reasoning was faulty, because the proper distinction was not made between bad open fractures which notoriously require a long period of time for proper cure, and uncomplicated closed fractures.

Dr. William Darrach, of Roosevelt Hospital, New York, has had a wide experience in the operative treatment of fractures, and is an earnest advocate of the method in a large range of cases. He says in his paper [5] read before the American Medical Association and published in August of this year that his experience has been that firm union comes a little more slowly in fractures that have been opened.

Another similar opinion is given by Dr. Astley P. C. Ashhurst [6] in his article on the treatment of fractures of the forearm, in which he gives the notes of 52 cases treated without operation. He states that if in treating these fractures the surgeon will use "the eyes in the ends of his fingers, he will secure by conservative means quite as good, and in many cases a much better result than by operation, and in a shorter time." In another part of his paper he gives as his opinion that after operation the process of union often is slower than it would have been if no operation had been employed.

One of the advocates of the rather frequent necessity for direct fixation of fractures is Dr. Leonard Freeman, of Colorado. His statement is that it is certain that delayed union is more common after operation than when fractures are treated by ordinary means.[7]

In a later article published in 1911,[8] when discussing the operative procedure, Dr. Freeman makes this statement: "All this gives rise to two dangers—infection and delayed or non-union." In the same article, he continues: "The tibia is one of the most frequent sites of delayed or non-union, and particularly is this true of fractures that have been operated upon and perhaps united by wires or bone plates. Fritz Koenig asserts that this is due to the removal of blood clots and tissue fragments, which are supposed to stimulate bony union, while others place the blame upon the foreign bodies introduced by the surgeons; but whatever the explanation may be, the fact remains." In the earlier article Dr. Freeman says that this delay in union may occur when the periosteum has not been disturbed and when no wires are employed. This seems to indicate that he attributes the slowness of bony repair to the operative intervention itself without reference to foreign bodies being used or the periosteum being unduly disturbed. In another part of his earlier article he speaks of the delayed union after operative intervention being more frequent when fractures of the femur are so treated than those of the tibia, and attributes this more frequently delayed union to the necessary disturbance of the tissues in a deeper wound.

Probably this experience of Dr. Freeman has something to do with his advocacy of subcutaneous fixation with long screws and an external clamp.

In an article in the *Journal of the American Medical Association* of October 21, 1911, Dr. Edward Martin, of Philadelphia, asserts that: "It is noteworthy that union is usually delayed, that the time of treatment is not materially shortened, that the results are not uniformly good. But taken as a whole, they are infinitely better than could possibly have been secured by other than operative means." He thinks: "There

has seemed to be a relation between the size of the internal splint and the promptness of final union. In other words, we have felt that the less foreign matter we put into the wound the quicker it got well." The same writer in an article on the open treatment of transverse fracture of the femoral shaft printed last year [9] makes the statement that union is nearly always delayed, the delay being proportionate to the amount of stripping of the bone ends and trauma of the soft parts at the time of operation. He thinks that we have no evidence that the period of after-treatment, before complete, or what we call complete, restoration of function is accomplished, is materially shortened by plating.

These opinions of Dr. Martin are confirmed by his statement made in September of this year [10] that as a rule the presence of a plate (Lane plate), instead of stimulating osteogenesis between the broken bone ends, retards it.

This statement of Martin is quoted by Dr. F. H. Albee [11] in his paper on bone transplantation in the treatment of Pott's disease, club-feet and ununited fracture as a reason for advocating the use of bone grafts in non-union of fractures.

These writers are not alone in the belief that direct fixation may be a cause of delay in union. William Hessert [12] has written that it has been his experience to see union delayed weeks, even months, though he has never had a case of infection.

S. C. Plummer, of Chicago,[13] states that he has heard Dr. John B. Murphy express the opinion that union was slower when a Lane plate had been applied. Plummer says that this has also been his experience in some cases. Plummer, therefore, does not agree with the opinion of Mr. Lane, whom he quotes [14] as making the statement that operative treatment "shortens the duration of the period during which he (the patient) is incapacitated for work, since union is practically by first intention, and, consequently, very rapid and perfect."

I finally give the opinion of Joseph A. Blake,[15] of New York, on this subject, which is valuable, because Dr. Blake has been greatly interested in the operative treatment of fractures and

has written a good deal in its favor. In speaking of non-union after the operative treatment of broken bones, he says: "The occurrence of non-union is not so very rare, even when the fragments have been maintained in end-to-end position by ordinary external splints. I have seen such results notably in the femur. I have also seen non-union occur when the femur had been wired. In these cases non-union has usually been attributed to the presence of the wire. When, however, the wire was changed for a plate which kept the fragments rigidly fixed, union resulted in spite of the presence of much more foreign material."

Many surgeons have probably seen this occurrence. I, myself, a good many years ago was unable to get union of an ununited fracture of the humerus by wiring, which another surgeon subsequently cured, I understood, by the insertion of a plate.

Blake further says that he has had three cases of mild infection after operations upon the femur in which there was a rather excessive production of callus. In these instances "union did not seem to be delayed, but even seemed to be accentuated." He makes the assertion that "mild infections apparently do not interfere with union, but, on the other hand, seem to stimulate the formation of callus." He maintains, however, that: "Infections severe enough to cause necrosis of tissue manifestly will prevent union." He calls attention to the fact that he does not look upon infection of such operative wounds with satisfaction, for infection must be considered, he says, "the worst misfortune that can happen in operations for fractures."

Plummer, in commenting upon the fact that slight degrees of sepsis seem to hasten union of the broken bone, truly says that all agree that the one chief and overwhelming cause of failure in the operative fixation of broken bones is sepsis.

I have reported my own case of apparent interference with union by operative fixation with a plate to maintain coaptation of the fragments after a difficult reduction. I have also gone over the recently expressed opinions of surgeons doing

this kind of work. My intention has not been to discourage the election of direct fixation in fractures, which are difficult to reduce or hard to maintain in position after reduction. This contribution is rather a plea for caution against the enthusiastic adoption of this method of treatment as a routine means of dealing with closed fractures. The profession and the public should know that while it is a necessity in some cases and its adoption a question of judgment in other cases, there are many instances of subcutaneous or closed fracture in which it is not needed. Good results can often be obtained, both as to anatomical restoration of the parts, good function and rapid cure, by external dressings guided by a thoughtful, careful surgeon, who has a mechanical mind and anatomical knowledge. The operative treatment is particularly dangerous when adopted by novices in aseptic surgery, or in places where complete aseptic surroundings cannot be obtained.

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TREATMENT OF VOLKMANN'S CONTRACTURE.

A REPORT OF TWO CASES WITH DESCRIPTION OF APPARATUS.

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NEARLY forty years have elapsed since Volkmann first described a peculiar contracture of the hand, which he believed due to an ischæmia of the muscles from a cutting off of the arterial blood supply. He believed that the usual cause was too tight bandaging in the treatment of fractures, but also stated that the condition might follow injury to the blood-vessels, compression, or cold.

Volkmann thought the condition to be the result of a myositis and not to a primary nerve involvement, basing his belief on the fact that the paralysis and contractures appeared almost simultaneously, while the contractures following nerve injury were delayed.

Many articles on this interesting subject have been written, but little, excepting the treatment, has been added to the causes, clinical description, and pathology, as described by Volkmann.

The pathology of Volkmann's contracture is still a mooted question. Many follow Volkmann and believe the condition to be a contracture myositis; others, that it is primarily muscular in origin, but that there is a secondary nerve involvement, and still others believe that the nerves are primarily at fault.

Thomas, of Boston, in an excellent article on this subject, read before the American Neurological Society, says that if the nerves are involved in producing the muscle changes it is in the terminal muscle branches and that this is of secondary importance, and that "the involvement of part of a muscle only by the connective-tissue formation with a good response

to the remaining portion of the muscle to electrical stimulation," shows "that the nerve involvement in the primary process is not a necessary factor." The same author also calls attention to the frequent secondary involvement of nerve trunks in connective-tissue overgrowth. To this involvement Thomas thinks are due the disturbance of sensation, the reaction of degeneration and the atrophy of the hand muscles, as are seen in some cases of Volkmann's contracture.

The treatment for the contracture first recommended by Volkmann consisted in stretching the contracted muscles under an anæsthetic. The other methods that have been recommended consist in the gradual stretching of the muscles by means of a splint and by operation.

The operations devised are, freeing the nerves from connective-tissue formation, myotomy, and tendon lengthening. either by operating directly upon the tendons, or indirectly, by removing a portion of the bones of the forearm.

Volkmann believed his method applicable to recent cases, but in old cases with marked cicatricial changes there was danger of fracturing the bones or rupturing the tendons. In direct tendon lengthening, the disadvantages are the danger of infection, the length of time required to perform the operation, and the adhesions that sometimes form around the tendons. The deformity it produces, the weakening of the extensor muscles, and the liability of infection or non-union must be thought of before undertaking bone resection. Freeing the nerves and myotomy have both been practised with some success. Jones has discarded all operative measures and relies entirely upon "mechanical and manipulation routine." His reasons for so doing are that operative measures are "hazardous and inadequate," as any open operation must be performed through tissues deficient in circulation and usually cicatricial. He also states that after operation "almost immediate mechanical strain" is necessary to correct the deformity.

The following two cases were treated by mechanical means.

electricity, and massage. One case was of short duration, the other had existed for several months.

CASE I.—A. W., female, age six years, was admitted to the Children's Hospital of the Mary J. Drexel Home in February, 1912, with the following history:

In June, 1911, the patient fell down a flight of stairs and sustained a T fracture of her right elbow. The fracture was treated with an anterior right-angle splint. The splint was too small, and when first applied was tightly bandaged to the arm and forearm. This caused so much pain that the bandages had to be loosened. The fracture was treated with this splint for six weeks, and on its removal, besides having a stiff elbow, it was noticed that the patient had a Volkmann's contracture. The limitation of motion of the elbow rapidly improved, but the Volkmann's contracture grew steadily worse. When seen by us the child showed a well-marked Volkmann's contracture of the right hand with atrophy of the muscles of the forearm, especially the flexors. The small muscles of the hand also showed atrophy. No accurate tests were made, but there was diminution of sensation in the hand. The muscles were not tested for degeneration. The circulation of the hand was impaired. If the hand was flexed to a right angle the patient could extend the fingers.

The case was treated on a splint, which I shall describe later, electricity and massage were given every other day, and the splint gradually extended. At the end of twelve weeks the case was discharged from the hospital cured, with good supination and pronation of the forearm, flexion and extension of the wrist and fingers. We heard from the patient a few days ago and no contractures have recurred.

CASE II.—H. S., male, age ten years, came to the Children's Hospital of the Mary J. Drexel Home from a neighboring city with the following history:

Five days before admission sustained a fracture in the neighborhood of the elbow-joint. Reduction was attempted and an anterior right-angle splint applied. The patient stated that the splint was tightly bandaged to his arm. As a result of the tight bandaging the fingers became blue, cold, and numb. The patient suffered intensely the first night following the accident and gained no relief until the dressings were removed. On admission

to the Drexel Home, five days after the accident, the arm and forearm were greatly swollen. The forearm was dusky, cold, and showed numerous blebs. On the flexor surface of the forearm, just below the elbow, was a large superficial ulcer. An X-ray examination showed an unreduced supracondylar fracture of the left humerus with the usual displacement of the fragments. All dressings were removed, the arm elevated and placed on a pillow, and hot antiseptic dressings applied. The circulation gradually improved, and at the end of a week, all fear of gangrene having passed, an anæsthetic was administered and an attempt made to reduce the fracture and the arm placed in the Jones position.

The patient remained in the hospital one month and was then discharged and referred to the dispensary. At the time of discharge he showed no sign of a contracture. About two weeks after leaving the hospital, and six weeks after the injury, it was noticed that he had a Volkmann's contracture. As the patient was not under my care when first treated in the dispensary, I do not know the muscle and nerve condition at that time other than the nerve involvement was very marked, as the patient told me that he accidentally placed his hand on a hot stove and received a severe burn without feeling any pain.

This case was treated as Case I, and in about three months' time was able to flex and extend the fingers and wrist. Although the patient has good wrist and finger motion, he still shows atrophy of the muscles of the forearm and hand. Sensation in the hand is apparently normal. (Figs. 1 and 2.)

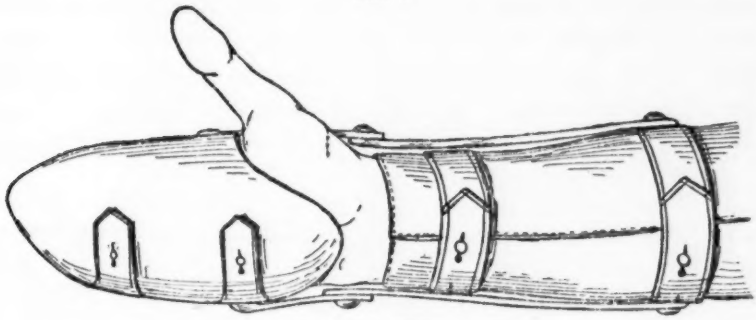
The only difficulty encountered in the treatment of these two cases was superficial pressure ulceration of the finger tips. This, I am sure, was due to faulty management and trying to produce too rapid an extension of the fingers. This difficulty we overcame by placing pads under the finger tips and "making haste slowly" with the extension.

Jones has noticed that, when the contracture has improved to such a degree as to permit hyperextension of the hand without a tendency to recurrence, the circulation will be found, as a rule, to have improved. He also claims that when the nerves are involved relaxation of the contracture is frequently accompanied by nerve improvement.

The apparatus used in treating the two cases reported consists of two parts.

Part 1 consists of a leather casing encircling the lower half of the forearm. The casing is reinforced on each side (radial

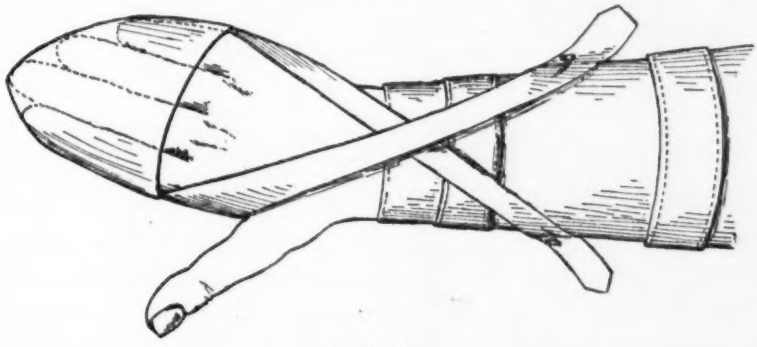
FIG. 1.



Palmar view.

and ulnar) by a steel bar. A semicircular bar at the upper end extends around the flexor surface from the radial to the ulnar bar. The casing is buckled on the extensor side of the forearm.

FIG. 2.



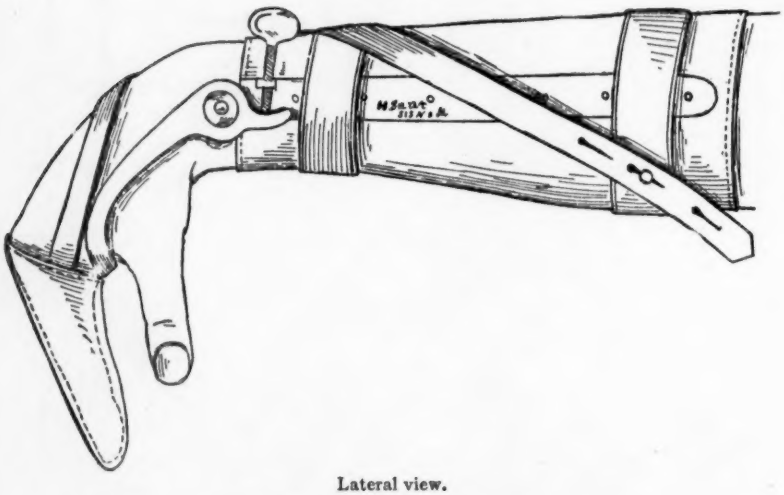
Dorsal view.

Part 2: A plate covered with leather is fitted to the palm of the hand and fingers. Extending from one side of the plate to the other, on the dorsal aspect, is a wide leather strap to hold the fingers straight and in position. Two bars attached in front on either side of the plate pass backward, the one on the radial side arching much more than the ulnar one, to join

at the wrist the radial and ulnar bars described in Part I. The joint formed by the union of these bars is provided with a lever and quick screw. Two long leather straps, attached in front at the junction of the plate and bars, pass backward, crossing on the dorsum of the wrist, and are attached to the radial and ulnar bars, just in front of junction of these bars with the semicircular one. These straps, and also the broad finger strap, are so arranged that they can be adjusted to fit the case.

The apparatus can be varied to suit the case. If much

FIG. 3.

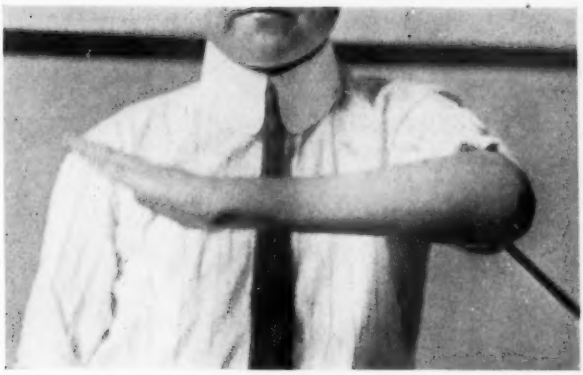


Lateral view.

trouble is encountered in preventing flexion of the wrist, greater fixation can be gained by having the leather casing buckled or laced on the flexor side of the forearm; if this is done the semicircular bar joining the radial and ulnar bars had best pass over the extensor side of the forearm. The long leather straps were not used in the first case, but in the second case they were found necessary to prevent the wrist from riding upward when extension was made on the fingers.

The apparatus is applied with the hand strongly flexed and the fingers extended as much as possible. By turning the screws the plate is elevated and the hand and fingers extended.

FIG. 4.



Case II. End result.

FIG. 5.

Case II. End result—apparatus applied.

INFECTIONS OF THE HAND.*

A REVIEW OF 90 CASES.

BY LEROY W. HOON, M.D.,

AND

GEORGE J. ROSS, M.D.,

OF PHILADELPHIA.

THIS study is based upon all the cases of infection of the hand treated in the German Hospital Surgical Dispensary from April 1, 1912, to October 1, 1912. Ninety cases in all were treated during these six months, and it is of incidental interest to note that during this period only five cases of infection of the foot presented themselves for treatment.

In the main we followed closely the anatomy, diagnosis, and treatment as urged by Allen B. Kanavel, of Chicago, in his most excellent book, "Infections of the Hand." This line of treatment was a radical departure in several respects from our former treatment, but as the first few cases so treated gave such splendid results, we have been using Kanavel's method or a modification ever since.

The less severe cases will be taken up first, as we wish to reserve the deep infections for more emphatic discussion. Under the less severe infections come felons, paronychiæ, carbuncles, furuncles, infected blisters and cuts, and other superficial infections.

Felons (Nine Cases).—By "felon" we mean an infection occurring within the closed connective-tissue space which exists in the pad over the palmar surface of the distal phalanx of the thumb and fingers. Seven of these cases were seen before pressure had shut off the vessels supplying the diaphysis of the distal phalanx and thereby caused osteoperiostitis. These cases were at once arrested, and made rapid and complete recovery by making a deep lateral incision, opening the periosteum to evacuate the pus, and dressing the part with hot, wet

* Read before the Philadelphia Academy of Surgery, December 2, 1912.

4 per cent. boric dressings for a day or two. Two of the cases already had osteoperiostitis of the diaphysis of the phalanx when first seen. The epiphysis was not involved in either case and immediate and complete removal of the diaphysis was practised. Both cases recovered with the joint intact and had a functionating stump. The Klapp suction cup and baking hastened the cure in one case. Nitrous oxide anæsthesia was used in all cases.

Paronychiæ (*Four Cases*).—These cases were all treated as advised by Kanavel, *i.e.*, under nitrous oxide anæsthesia a longitudinal incision was made along the lateral edge of the nail, going back as far as the sulcus and being especially careful not to cut the nail bed or overhanging cuticle. The eponychium was then pushed back, point of scissors inserted beneath the detached edge of the nail, and as much of the nail as had been lifted from the nail bed by pus was snipped off. Subsequent dressings of hot, wet boric for two or three days, followed by dry dressings, rapidly cleared up all four cases.

Carbuncles, Furuncles, Infected Blisters and Cuts, with other Superficial Infections (*Fifty-four Cases*).—Carbuncles and furuncles were treated under nitrous oxide anæsthesia by crucial incisions extending beyond the indurated area, followed by thorough undercutting of all four flaps. Squeezing of pus outward was avoided, and for two or three days following wet boric dressings were used. Recovery was hastened by the suction cup in several cases. Necrosis of the flaps was conspicuously absent and thereby less scarring resulted. Perfect drainage occurred. The infected blisters and cuts were opened where needed, and hot, wet boric dressings applied until the discharge began to thin, when iodine and dry dressings were used.

Every one of these 54 cases was saved from becoming a deeper infection by these simple means.

Having disposed of these less serious cases, we now approach the deep infections of the hand—those hidden struggles between microbe and body protoplasm deep in fascial space or tendon sheath, the prize of battle being a pliant, useful hand, or the pathetically twisted "claw hand" so often seen.

Twenty-three cases of this nature were treated, and in comparison with the usual outcome in such cases the end results were most gratifying. An outline of the anatomy and operative incisions advocated by Kanavel should precede any discussion of these cases.

ANATOMY.

The anatomical knowledge needed is not so much a knowledge of the attachments of the palmar fascia and superficial transverse ligament, palmar arterial arches, and anterior annular ligament as it is an understanding of the fascial spaces and flexor tendon sheaths.

Pus may collect in the following six fascial spaces:

1. Dorsal subcutaneous, an extensive area of loose tissue over the extensor tendons of the back of the hand.

2. Dorsal subaponeurotic space, lying between the extensor tendons and the metacarpal bones.

3. The hypothenar space, an unimportant intermuscular space occupying the hypothenar eminence. Pus located here would not burrow into deeper spaces, but would spread to the surface.

4. The thenar space, an important space in the thenar eminence. It lies entirely to the radial side of the middle metacarpal and upon the palmar side of the adductor transversus muscle.

5. The middle palmar space, another important space, lying between the metacarpals and deep flexor tendons and extending from the middle metacarpal bone to the fifth metacarpal, and having extensions along the three outer lumbricals into the webs.

6. The web space, a subcutaneous space in the finger webs.

Besides these fascial spaces, the following flexor tendon sheaths are of the utmost importance:

1. The tendon sheaths of the index, middle, and ring fingers, extending from the middle of the distal phalanx to a line joining the ulnar end of the distal palmar crease and the radial end of the proximal palmar crease (Kanavel's line).

2. The tendon sheath of the flexor longus pollicus and

radial bursa. This extends from the base of the distal phalanx and when connected to the radial bursa (as it is in 19 out of 20 cases, Poirier) it extends to the lower end of the radius.

3. The tendon sheath of the little finger and the ulnar bursa, when connected (as in 50 per cent. of cases) extends from the distal phalanx of the little finger to the lower end of the ulna.

INCISIONS USED IN OPENING FASCIAL SPACES AND TENDON SHEATHS.

These incisions offer the most intelligent approach to deep pus pockets with the best drainage and least amount of after-scarring:

1. The tendon sheaths along the fingers are opened laterally along the proximal and middle phalanges; if sufficient drainage is not gained by these incisions, we may open laterally opposite the proximal interphalangeal joint as well.

2. The thenar tendon sheath may be split up to a thumb's breadth distal to the anterior annular ligament so as to avoid cutting the motor nerve going to the thenar eminence and thereby destroying apposition of the thumb.

3. The hypothenar tendon sheath may be cut from the base of the little finger up to the anterior annular ligament.

4. The ulnar or radial bursæ above the wrist. One incision is made on the ulnar side 1½ inches above the tip of the ulna and extending down to and across the flexor surface of the ulna. A closed hæmostat is now thrust across both ulna and radius and pronator quadratus, and a counter-incision made upon the radial side of the wrist, where the hæmostat shows beneath the skin. These incisions should both be enlarged to 1½ inches up the forearm.

5. The middle palmar space. This is opened by cutting into the lumbrical canals, preferably choosing the one between the middle and ring fingers. This incision may be carried 1½ thumb breadths up the palm and a hæmostat thrust beneath the deep flexors into the middle palmar space (Besley).

6. Combined opening of the middle palmar and thenar space. A hæmostat is pushed through the incision just de-

scribed for opening the middle palmar space, pushed across the middle metacarpal bone through the thin partition between this space and the thenar space, and on across the adductor transversus muscle to the dorsum between the first and second metacarpals at about the middle of the second metacarpal. A counter-incision is made here and a rubber dam drain left in for about 18 hours as a rule.

7. Combined opening of the middle palmar space and subaponeurotic space. In the space between the middle and ring metacarpals where the middle palmar crease crosses, an incision is made and a hæmostat thrust through to the dorsum, where a counter-incision is made.

8. The thenar space. This may be opened by one incision through the dorsum on the radial side of the second metacarpal opposite the middle of that bone and on a level with its flexor surface. A hæmostat is then thrust through into the thenar space, being careful not to go beyond the middle metacarpal. No counter-opening on the palm is needed.

9. The subaponeurotic space is drained by adequate incision upon the dorsum over the interosseous spaces.

10. The hypothenar space is opened as any minor localized infection by direct incision.

DISCUSSION OF THE CASES OF DEEP INFECTION TREATED.

During the six months' period, 23 cases of this nature presented themselves for treatment, having infections classified as follows:

Tendon sheath infections	10
Middle palmar space infections	14
Thenar space infections	4
Collar button abscess at web	4
Dorsal subcutaneous infections	2
Dorsal subaponeurotic infections	2
Hypothenar space infections	1

The average age of these cases was 28 years, 19 were male and 4 female. Regarding cause, 9 arose from infected cuts, etc., 5 from infected blisters, 1 from a bruise, and 8

from unknown cause. Six days was the average elapsed time between onset and first visit to the dispensary. The most prominent symptoms were pain, disability, and loss of sleep. Constitutional symptoms as chill, fever, and loss of appetite were present in about one-half of cases.

In diagnosing the location of pus, the most valuable aids were as follows:

1. In the frog felons or collar button abscess, web tenderness and redness, and a semiflexed position of the adjacent fingers.

2. In the tendon sheath infections, exquisite and unmistakable tenderness over the course of the sheath, a flexed position of the finger, and great pain upon attempting to passively extend the finger, were the three cardinal signs. Necrosis of tendon had already occurred in five cases, and necrosis of bone in three cases.

3. In the fascial space infections, the chief signs were localized tenderness over the thenar or middle palmar space, induration, flexion of the fingers with painful extension, loss of concavity of the palm with slight convexity in middle palmar infection, and ballooning of the thenar eminence with pushing outward of the first metacarpal in thenar space infections. Œdema and redness of the back of the hand was an ever-present feature, but tenderness was much less than that of the palmar surface, and in only three cases was pus present in the dorsum, this being diagnosed chiefly by induration.

As to treatment of these 23 cases, the incisions recommended by Kanavel were faithfully followed, with one exception, which will be discussed later. Nitrous oxide and oxygen anæsthesia was sufficient in 18 cases, ether being used in five cases. Preliminary bandaging of the forearm and arm above the operative field with elastic rubber bandages was tried in the first two cases. Kanavel advises this procedure in order to render the operative area bloodless and by subsequent gradual loosening over a period of about 18 hours to gradually allow the newly liberated toxins to enter the circulation, and thereby give the system a chance to form defensive products. After carefully observing the effect upon these two cases, this pro-

cedure was abandoned as an unnecessary elaboration of technic, no deterioration of results being noted in the other cases. Irrigation of the infected areas after incision was also abandoned after using it in eight cases, and a rigid avoidance of any forcible squeezing or attempts to milk pus out of deep areas was practised in all cases. If adequate incision was made and wet hot boric dressings applied until the parts were draining freely, we found that the subsequent profuse and at first almost alarming discharge of thick clotted pus so moistened the edges of the incisions leading to the pus pockets as to preclude any danger of these incisions glueing shut.

In cases where tendon sheaths had been incised, the hand and fingers were dressed in extension with a wooden dorsal splint until all danger of tendon prolapse was past.

Passive motion of the fingers and hand was started on an average upon the second day after operation, and no extension of infection occurred from this practice. Exploratory incisions into areas which proved to be free from infection were made in seven of the cases, only one of these subsequently becoming infected—this case cleared up long before the original infection and did no ultimate harm.

Hot boric dressings were kept up on an average three days after operation, and were then discarded for dry dressing. Secondary operation was required in nine cases and secondary arterial hemorrhage (from a digital artery) occurred in only one case. Perfect restoration of function was secured in 18 cases and partial restoration in five cases, these latter cases already having developed bone or tendon necrosis before applying for treatment.

RÉSUMÉ.

In the 90 cases studied we wish to emphasize these points:

1. The 67 cases of simpler infection were all saved from becoming serious infections by the simple treatment outlined above.

2. The beautifully simple anatomy of the hand and forearm in relation to infective processes as emphasized by Kanavel forms an amply sufficient foundation upon which can be

successfully built up treatment for simple or grave infections of these parts.

3. For the 23 cases of deep infection, the incisions recommended by Kanavel resulted in the most perfect restoration of function with the least after-scarring.

4. An utter disregard of the so-called danger of opening up uninfected areas in the hunt for pus did not result in harm. Incisions into doubtful areas were always made before opening into obviously pus-filled areas. In our future cases we intend to open up areas in which we cannot say definitely whether there is or is not pus, using the same incision as should be employed for opening up obviously infected pockets.

5. Rendering the operative field bloodless before operation and subsequent gradual release of the bandage is an unnecessary procedure.

6. Conservative irrigation did no harm, but just as good or better results were obtained by merely washing off what pus could be brought out by very gentle pressure.

7. Bending or extending of the fingers in a day or so after operation was found to be entirely free from danger of spreading the infection and of paramount value to the patient in securing for him an afterwards useful hand.

8. Incisions upon the back of the hand are rarely needed. The redness and œdema commonly present upon the dorsum in these cases is extremely dangerous because it often leads the uncertain practitioner to cut into pus-free areas, and then, finding no pus, to adopt one of the fatal policies of poulticing or waiting until the abscess shall "come to a head." Meanwhile the increasing infection may cause bone or tendon necrosis with crippling, that no amount of carefully made incision or faithful post-operative massage will wipe out.

9. Hot boric dressings, the dorsal splint, and flat rubber dam drains (never tubing) as used above form an indispensable trio.

10. All cases treated as we have described recovered perfect function excepting those few cases where necrosis of bone or tendon was present when the patient was first seen.

TRANSACTIONS

OF THE

PHILADELPHIA ACADEMY OF SURGERY.

Stated Meeting held December 2, 1912.

DR. GWILYM G. DAVIS, President, in the Chair.

INFECTIONS OF THE HAND.

DR. LEROY W. HOON and DR. GEORGE J. ROSS presented a paper entitled "Review of Ninety Cases of Infections of the Hand," and exhibited a number of patients. For this paper see page 561.

APPARATUS FOR THE TREATMENT OF VOLKMANN'S CONTRACTURE.

DR. EMORY G. ALEXANDER read a paper with this title, and presented the apparatus described. See page 555.

DR. GWILYM G. DAVIS reported two cases to illustrate the method of treatment adopted. He stated in preliminary that as to the etiology, the relative part played by the nerves and muscles is a matter of dispute. In his opinion the muscles are probably more affected than the nerves, although both may be involved. In many of these cases, the site of probable lesion is indicated by a scar on the forearm; both cases here reported had such scars. They are usually situated lower than the point of entrance of the nerve into the muscle, hence the latter escaped injury. The involvement of the nerves in these cases is not before they enter the forearm muscle, but of those nerves which lie between the muscles and tendons, and muscular disturbances due to such involvement are shown by atrophy and paralysis of the intrinsic muscles of the hand and not of those muscles which arise high up in the forearm. The nerves are apt to be involved only when all the adjacent muscles and tendons are matted together.

Injuries to the nerves in the region of the elbow will however

produce muscular contractions which bear some resemblance to that produced by Volkmann's palsy, but the nerve lesion is more likely to manifest itself in the claw hand of Duchenne, while the muscular lesion exhibits a flexed wrist and contraction of most of the flexors of the fingers. The difference in the appearance of the hand and fingers in the two conditions is characteristic and is evidence of a nerve lesion as being the cause of one and the muscle lesion as being the cause of the other. As has, however, been stated there is undoubted nerve involvement in some of the true ischæmic cases.

In the treatment of these cases, Mr. Jones, of Liverpool, strongly advises persistent stretching, and his results show that very much can be accomplished by that method of treatment. It is a long and tedious undertaking, which is not always feasible to carry out. The cases here given will show what has been accomplished by tendon lengthening. Even resection of both bones of the forearm will in some cases add greatly to the use of the member.

CASE I.—A boy, aged 11 years, had fractured his forearm five years previously. On the second day after the injury the bones came through the skin and were replaced under ether and the arm put up in splints. The contraction of the hand and fingers was said to have begun while the splints were still on, and now the contraction of the hand and fingers is very marked and they are almost entirely useless. This boy was treated persistently for two or three years with splints and apparatus made by his father, who is a skilful instrument maker.

An incision about three inches long was made down the ulnar side of the forearm, extending just above the pisiform bone. To this was added a transverse one directly across the wrist to the radial side. This flap was then raised and the tendons exposed. The palmaris longus, flexor carpi radialis, and the superficial and deep flexor tendons of the four fingers, ten tendons in all, were then cut and lengthened about half an inch, enough to allow the finger to be straightened. The median and ulnar nerves were not much involved. The tendons were then separated as much as possible by means of the adjacent fat and connective tissue, and the wound closed without drainage. Healing was uneventful. It is now five years since the operation and the patient is working in a grocery store and uses his hand quite well. When last seen, about a year after the operation, the result was almost perfect.

Now, after the lapse of four years, there seems to be a small amount of contraction again present, but still the hand is a very good and useful one.

CASE II.—This was a boy aged 7 years. He broke his forearm twice, two months apart, and the contraction was noticed after the second break as soon as the splints were removed. He had marked deformity with the hand firmly flexed on the forearm at a right angle and the fingers strongly contracted. He applied for treatment about five months after the last injury. This boy came from a distance and it was practically impossible to give him the necessary attention if simply stretching was to be employed, and in view of the satisfactory result of the previous case and the difficulties experienced in carrying out the stretching treatment it was decided to operate. In this case a median incision was made and the sublime and deep flexor tendons of the index, middle, and ring fingers were divided and lengthened sufficiently to allow them to come out straight. Fine silk was used to unite the divided tendons. In two weeks the plaster cast was removed and a sinus was found in the line of the incision which had been made through a scar which was present. A couple of pieces of fine silk came out and the wound after several weeks finally closed. Despite this occurrence the result was almost a perfect one, and now, one year after the operation, extension is perfect, but the fingers when voluntarily flexed do not quite touch the palm. He is using the hand well and is learning to write with it.

In both of these cases, when the proximal and middle phalanges are held firmly, the distal phalanges of each of the fingers operated on can be individually flexed, thus showing that adhesion between the superficial and deep flexor tendons is not present. Operation is not advised in all cases, but only in those in which for any reason the conservative methods of treatment are considered unsuitable.

DR. FRANCIS T. STEWART said that he had treated one case of this condition like Dr. Davis, and although he secured vast improvement it was not nearly so great as in the cases reported by Dr. Davis. There is one objection to an apparatus of the kind which Dr. Alexander has shown: it provides the very condition that, in the first place, originated the contracture, that is, constant pressure. In one case he had ulceration as a result of this pressure. The pathology of Volkmann's contracture is not by any

means clear. It is of some importance from a medicolegal standpoint to know that a few cases do not follow the application of a bandage, but result from a simple contusion. These contractures have more than one point in common with the contractures of the sternomastoid, where a bandage is almost never applied. The ischæmic theory has always seemed to him to be unsatisfactory. It may be that the condition is due to infiltration of the muscle with blood, and that this induces inflammation and subsequently fibrous overgrowth. This condition occurs almost entirely in children; very few patients are more than 12 or 15 years of age. Perhaps it is because the muscular tissue of adults is tougher than that of children.

Dr. John H. Jopson referred to a case reported here a year or two ago, in which he operated by lengthening the tendons of the muscles, but improvement has not been very marked. The condition was a very advanced one, the degeneration of the muscles amounting to complete alteration of the normal appearance of the muscle tissue. The muscles were yellow and brittle in appearance, and it seemed impossible to get any recovery of contractile joints. The nerves also showed marked alteration. They looked as if pinched between the contracting muscle fibres and were markedly atrophied for two or three inches.

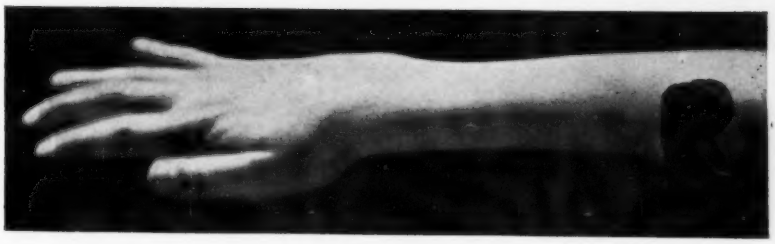
Dr. John H. Gibbon said that he had seen a case of Volkmann's contracture following the placing of the arm in Jones's position where no bandage whatever was applied about the arm. He saw the patient when the accident occurred and placed the arm in this position, and did not see it again for some time. A number of weeks later the child had a Volkmann's contracture. It was due to swelling, the arm not being brought down as it should have been.

Dr. Davis remarked, apropos of the cause as to whether it is nervous or muscular, that in a good many of these cases there is an injury visible on the forearm, and the cicatrix in most of those that he had seen had been below the entrance of the nerve into the muscle; if, however, the nerves have been injured at the site of the injury of soft parts, the injury will show itself lower down, not only in disturbance in sensation but in the paralysis and atrophy of the intrinsic hand muscles. In a good many of these cases the hand-muscles do not appear to be atrophied, and

FIG. 1.

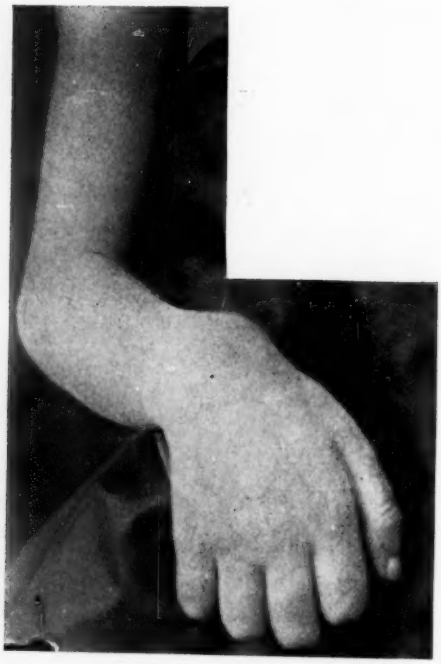
Case I. Before operation.

FIG. 2.



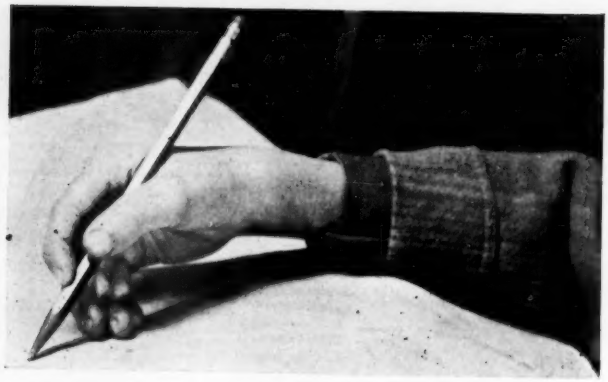
Case I. After operation.

FIG. 3.



Case II. Before operation.

FIG. 4.



Case II. After operation.

FIG. 5.

Case II. After operation.

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the affection of the nerves may be due to their inclusion in the inflammatory process and the exudate which occurs after the injury. An interesting question is as to the treatment which shall be adopted in these cases in which a trial by stretching has been made and has failed. What shall be done after that? and on that point his two cases show what may be accomplished by tendon lengthening. In the small boy the result is almost perfect. In the older boy who had the deformity for five years, although he has not an absolutely perfect result, yet the hand is very useful and shows that a great deal can be done by operative means. Not much has been said about resection of the bones for this condition, but even that at times will be much better than leaving the cases alone.

DR. EMORY G. ALEXANDER (in closing) remarked, as to Dr. Stewart's criticism, that the apparatus is apt to produce the same conditions that cause a Volkmann's contracture. The pressure exerted by the apparatus is not constricting, therefore it does not cut off the circulation. The worst that can happen by improper use of the splint is superficial ulceration of the finger tips. There is no constriction of the forearm and the slight pressure exerted by the semicircular bar is not sufficient to do any harm.

As to the cause of the contracture, Volkmann thought that venous stasis played some part in causing or hastening the contracture. The fact that the condition has followed injury to blood-vessel, embolism, and constriction by an Esmarch band seems to prove that it is ischæmic in origin. Although attempts to produce the condition experimentally have not been successful, it may be possible that other causes than ischæmia, either combined with or the result of circulatory disturbances, are associated in producing the contracture.

It is of interest to note that all of the cases reported at this meeting give a history of too tight bandaging. A very famous American surgeon claims that Volkmann's contracture is a "surgeon's lesion." While he did not agree with such a broad assertion, certainly in the majority of instances the contracture could be prevented if proper care were exercised in the application of constricting dressings in the treatment of fractures in the neighborhood of elbow-joints.

A very important advantage gained by mechanical treatment, according to Jones, is that the structures are stretched in the order of their tension, and that the deep structures which are impossible to divide at operations may thus be elongated.

ARTERIOVENOUS ANEURISM TREATED BY ANGEIORRHAPHY.

DR. FRANCIS T. STEWART presented a boy, aged 7 years, who was admitted to the Pennsylvania Hospital, Nov. 27, 1911. Four years before this date he was circumcised by his physician. During the operation the knife was laid on the left groin, and as the patient was not completely relaxed by the anæsthetic he suddenly flexed his left thigh, impaling it on the knife. This was followed by a furious hemorrhage, which was controlled by enlarging the wound and applying ligatures. It was thought at the time that the femoral artery had been included in one of these ligatures. About one month after the injury a soft systolic murmur was noticed over the right heart, and later distinct enlargement of the heart was detected.

On admission to the hospital there was a scar about the middle of the anterior surface of the left thigh, and over this point a continuous thrill could be felt and a continuous bruit heard, the latter being transmitted down the femoral vessels as far as the knee and up as far as Poupart's ligament. Both thrill and bruit were reinforced at each arterial systole, and both ceased when firm compression was made over the scar, or over the artery above the scar, but this compression did not seem to have any influence on the cardiac murmur. There was no appreciable difference between the pulsations in the right and the left tibial arteries. The entire lower extremity was bluish in appearance, owing to the large number of dilated venules that ramified through and beneath the skin. In none of these venules could pulsation be demonstrated; there were no large veins. The left leg was one inch longer than the right and one-half inch greater in circumference, but there was no œdema.

Under ether anæsthesia the femoral vessels were exposed above the scar and then traced downward. No tourniquet was applied, and many ligatures were needed to check the bleeding from the dilated veins. The vessels were adherent for about one-half inch, and there was no sign of a sac between them.

After an assistant had grasped the artery and the vein on each side of the adherent point the vessels were separated with a sharp knife and the opening in each, which measured about one-eighth of an inch in diameter, closed with sutures of fine silk. A flap of the vastus internus was then passed around the artery so as to form a canal for it and separate it from the vein. The muscles, the fascia, and the skin were next closed, without drainage, the limb placed on a splint, and a tourniquet applied loosely to the root of the thigh, so that if bleeding should occur the nurse could at once control it. The pulse in the foot reappeared, full volume, as soon as the blood current was turned on, and continued undiminished as long as the patient was under observation. The murmur over the right heart could no longer be heard after the operation, and the heart diminished considerably in size before the patient was discharged, Dec. 8, 1911, 10 days after the operation. The only unpleasant feature in the case was a small stitch abscess at the upper angle of the wound.

Dr. Stewart remarked that, as far as he was aware, attention had not been directed to the possible influence of an arteriovenous aneurism on the cardiac muscle, although one can readily understand how the right heart might dilate under the strain of the large amount of blood delivered to it under high pressure and with increased velocity, the strain being proportionate to the size of the involved vessels, to their proximity to the heart, and to the size and directness of the orifice of communication between the artery and the vein. In a case of arteriovenous aneurism of the subclavian vessels which he had the opportunity of examining recently, thanks to Dr. Gibbon, under whose care the patient was admitted to the Pennsylvania Hospital, another factor increasing the strain on the heart was found. The veins of the upper extremity were thrombosed, and almost all the blood from the artery was turned back into the right heart, which was dilated. The aneurismal bruit was transmitted to the heart and along the pulmonary arteries, but when the aneurism was compressed no murmur could be heard over the heart. In the present case the cardiac murmur was apparently due to dilatation, since it subsided promptly after operation. If it had been transmitted from the aneurism it would have been heard over the abdomen, would have ceased when compression was made over the aneurism, and would not have been punctually systolic,

but post-systolic, because of the time necessarily elapsing between the contraction of the heart, the production of the murmur in the aneurism, and its propagation back to the heart. That it might have been intermittent and still due solely to the aneurism may be possible, since the weaker portion of the murmur might have been lost in the journey from the middle of the thigh to the heart.

Increase in the length of the limb has occurred in other cases (Franz, Cordonnier), and appears easy to explain, until one reads, as in Brindejone's case, that the limbs may be shorter and thinner than normal. Perhaps the size of the orifice of communication may have some influence on the growth of the limb. If it is small, as in this case, the arterial current is not diverted completely, hence the arteries below the fistula do not atrophy, but continue to irrigate the extremity with almost a normal quantity of pure blood. Further, the amount of arterial blood diverted may be just enough to enrich the venous current without seriously obstructing it. In such an event, which is well illustrated by this case, the circulation would remain active and there would be little or no œdema. If, on the contrary, the abnormal opening were very large, practically all of the arterial blood would pass into the vein, because of the lower pressure on the venous side of the circulatory apparatus, and most of this blood would be hurried directly back to the heart through the central segment of the vein, while the rest would distend the peripheral segment and prevent the return flow of the venous current; in addition the arteries distal to the aneurism would shrink and there would be passive congestion, œdema, and atrophy. In some cases, of course, the malnutrition may be augmented by atheroma, thrombosis, injury to the nerves, destruction of the collateral vessels, cardiac disease, or some debilitating malady of a general nature.

As to the treatment separation of the vessels, with excision of the sac, if such there be, and suture of the opening in the artery and in the vein is the ideal method in all cases in which the major vessels are involved and in which this operation is possible. Extirpation of the aneurism, after ligation of both artery and vein above and below, is the only rival of angeiorrhaphy, and it must be confessed is a formidable rival, since it precludes recurrence, and, contrary to what one would expect

from a study of the statistics of ligation, is rarely followed by gangrene. Ligation of the subclavian artery causes gangrene in 2 per cent. of the cases (von Bergmann), of the axillary in 6.6 per cent., of the brachial in 18.75 per cent., of the common femoral in from 19 to 21 per cent. (Raabe), of both femoral artery and vein in from 48.3 per cent. (Ziegler) to 60 per cent. (von Bergmann), of the popliteal in 54.5 per cent., of both popliteal artery and vein in all. In 105 extirpations for arteriovenous aneurism, taken from the tables of Delbet and Monod and Vanverts, 99 were followed by recovery, 4 by death, and 3 by gangrene, one case of gangrene being due to ligation for secondary hemorrhage. These cases, among which are not included extirpations of arteriovenous aneurisms of the head, face, neck, and foot, in which there is no danger of gangrene or other serious disturbance in the parts supplied by the artery, are distributed as follows: common carotid 3, with 3 recoveries; external carotid 3, with 3 recoveries; subclavian 2, with 1 recovery, and 1 death within a few hours; axillary 6, with 6 recoveries; brachial 12, with 1 death from erysipelas; common femoral 12, with 12 recoveries; superficial femoral 24, with 23 recoveries, and 1 death within a few hours; deep femoral 1, with 1 recovery; popliteal 28, with 25 recoveries, 1 death on the second day, one gangrene followed by amputation, and 1 partial gangrene of the foot and permanent œdema; tibials and peroneal 14, with 13 recoveries, and 1 death (anterior tibial). In the last case extirpation was followed by sepsis and secondary hemorrhage, necessitating ligation of the popliteal, then of the femoral, and finally amputation for gangrene. Extirpation we would reserve for arteriovenous aneurism involving vessels of the second class, *i.e.*, vessels whose removal would not cause gangrene or other grave nutritional changes in the parts irrigated by the artery, and for most cases in which angeiorrhaphy is not feasible.

The ligation methods cannot be wholly discarded however, for in some instances neither angeiorrhaphy nor extirpation can be performed, either because of the relations of the aneurism or because of the condition of the patient. Quadruple ligation, *i.e.*, ligation of the artery and the vein above and below the aneurism, is the best of these methods, but so far as gangrene is concerned is no safer than extirpation, and, owing to the presence of col-

TABLE OF CONSERVATIVE OPERATIONS FOR ARTERIOVENOUS ANEURISM.

Name of operator.	Date of operation.	Vessels.	Age of patient.	Cause.	Time between accident and operation.	Operation.	Result.	Pulse.
1. Vean.....	1906	Axillary	15	Stab	2 months	Double ligation of artery, suture of vein.	Cure	?
2. Marchant...	1898	Brachial	?	Stab	2 months	Suture of artery and vein.	Cure	Reappeared in ¾ of hour then grew fainter.
3. Van Imschoot	1903	Brachial	26	Stab	?	Ligation of canal between artery and vein, ligation of vein.	Cure	?
4. Protherat....	1907	Brachial	19	Stab	?	Suture of artery and vein.	Cure	?
5. Doyen.....	1908	Brachial	11	?	?	Suture of artery and vein.	Cure	?
6. Auvray.....	1909	Common femoral	15	Stab	1 month	Suture of artery, lateral ligature of vein.	Cure	Persistent.
7. Montaz.....	1893	Superficial femoral	16	?	?	Double ligation of artery, lateral ligature of vein.	Cure	?
8. Garrè.....	1904	Superficial femoral	16	Stab	10 years	Suture of artery, double ligation of vein.	Cure	?
9. Gessner.....	1906	Superficial femoral	22	Gunshot	12 years	Intrasaccular suture of opening into artery and both ends of vein (restorative endo-aneurysmorrhaphy)	Cure	Persistent.
10. Westergard..	1907	Superficial femoral	19	Stab	3 years	Double ligation of artery, lateral ligature of vein.	Cure	?
11. Abalos.....	1909	Superficial femoral	19	Gunshot	?	Suture of artery and vein.	Cure	?

12. Zeidler.....	1910	Superficial femoral	18	Gunshot	2 months	Suture of artery and vein.	Cure	Persistent.
13. LeConte and Stewart	1912	Superficial femoral	7	Stab	4 years	Suture of artery and vein.	Cure	Persistent.
14. Bramann....	1906	Superficial femoral vein, deep femoral artery	17	Stab	?	Double ligation of artery, lateral ligature of vein.	Cure	?
15. Manteuffel...	1895	Deep femoral	18	Gunshot	?	Suture of artery, resection of vein.	Cure	?
16. Wiesinger....	1904	Popliteal	18	Gunshot	?	Suture of artery and vein.	Cure	Persistent.
17. Cranwell....	1906	Popliteal	21	Stab	?	Lateral ligature of artery and vein.	Cure	?
18. VanEiselberg	1906	Popliteal	38	?	?	Ligation of canal between artery and vein.	Recurrence in 3 weeks; extirpation.	?
19. Lexer.....	1907	Popliteal	34	Stab	?	Resection and anastomosis of artery and vein.	Cure	Persistent.
20. Sabadini....	1908	Popliteal	19	Stab	?	Lateral ligature of artery and vein.	Cure	?
21. Garrè.....	1908	Popliteal	16	Explosion	1½ years	Resection, anastomosis of artery, double ligation of vein.	Cure	Persistent.
22. Aubert.....	1910	Popliteal	?	Gunshot	?	Double ligation of artery, suture of vein.	Cure	?
23. DaCosta....	1912	Popliteal	29	Gunshot	3 months	Longitudinal incision of vein, suture of opening in artery from within the vein, division of vein on each side of the opening, with utilization of the flap of vein to reinforce the arterial suture, anastomosis of the vein.	Cure	Persistent.

lateral vessels that sometimes empty into the sac, is more likely to be followed by recurrence.

With angeiorrhaphy the aneurism can be dealt with radically and the vessels conservatively, thus effecting cure without interrupting the blood stream and without producing gangrene. Unfortunately suture of the vessels is not always possible. In a number of instances the surgeon has attacked the aneurism with vascular suture in mind but was forced to abandon the idea because of hemorrhage (Delanglade), friability of the artery (Thompson), the large size of the opening (Mignon), or because of dense adhesions (Cranwell, J. C. Stewart). Cestan found, after suturing the brachial artery and vein, that the vessels at the sutured point had been obliterated, hence proceeded with resection. Furthermore, in a number of cases the operator, owing to unforeseen difficulties, was compelled to alter his original plan, so that numerous modifications of the typical and ideal method have been adopted. Instead of analyzing these modifications we have considered it best to include them in the subjoined table, in which these cases are grouped according to the vessels affected. It will be noticed that in the 23 cases there was no fatal result and only one recurrence (Case 18). This list, it must be explained, does not contain the cases of arteriovenous wounds that were sutured soon after the accident, of which there are about 10 on record (Matas, Murphy, Lund, Perugniez, Lissjanski, Oliver, Rost, Sonnenberg, Körte, Stewart). Such cases we believe should be classed, not with arteriovenous aneurism, but with vascular wounds, since in the latter instead of dense adhesions there is a hæmatoma (false traumatic aneurism), and additional factors, *e.g.*, pre-operative hemorrhage, shock, and infection, come into play.

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Dr. John H. Gibbon remarked as to the case referred to by Dr. Stewart which recently was under his care at the Pennsylvania Hospital and in which he did not operate. This man had a gunshot wound, the bullet passing between the subclavian vessels and lodging in the trapezius. He was laid up for two weeks, went back to work, then developed a weakness in the left arm and suffered pain. With this condition he was admitted to the hospital; there was a marked thrill and evident arteriovenous aneurism. Dr. Gibbon was quite keen to operate on him, but waited a few days and in that time he showed a great deal of improvement, the pain got very much less, and finally disappeared altogether, the weakness in his arm disappeared until his grip was as good as in the other, and he was finally allowed to go home. He had an arteriovenous fistula, no aneurismal sac, and notwithstanding the heart changes which Dr. Stewart refers to it was the wiser thing to let this man go and operate later if his heart condition became so bad as to demand operation. If the heart condition which Dr. Stewart found in the boy, which had lasted four years, disappeared within ten days, there was no reason in this case not to wait and watch the progess. Another reason why he did not operate on him was that one is not always as successful in arteriorrhaphy as Dr. Stewart was in his case. In a great many of these cases, unless done by such men as Carrel or Sweet, one will get a thrombosis of the vessel and if this man got a thrombosis of his subclavian he would be in a great deal worse condition than he is now.

THE EFFECT OF THE REMOVAL OF THE HYPOPHYSIS IN THE DOG.

Dr. J. E. Sweet and Dr. A. R. Allen (by invitation) presented a paper with this title, for which see page 485.

Dr. Charles H. Frazier remarked, with regard to the conflicting testimony as to whether the pituitary body is essential to life, that it seemed to him as time goes on that the evidence is accumulating in favor of the position which he has taken. Dr. Sweet will remember a rather crude technic which together they employed five years ago for the removal of the hypophysis. An incision was made through the pharynx exposing the vault; by removing a button of bone with a small conical trephine the sella turcica was opened and the pituitary body exposed; the opportunities for infection were so great and the exposure so limited that complete and satisfactory removal of the pituitary body was not practicable.

TRANSACTIONS

OF THE

NEW YORK SURGICAL SOCIETY.

Stated Meeting, held at the New York Academy of Medicine, January 8, 1913.

The President, Dr. Charles L. Gibson, in the Chair.

FRACTURE OF THE PATELLA: BLAKE OPERATION.

Dr. W. S. Schley presented a man, 23 years old, who three days before his admission to the hospital had fallen down five steps of a flight of stairs. He did not strike the knee at any time, but on attempting to rise he found that he had no power in the leg and could not support himself. He had not suffered any pain, he did not hear the bone snap and was not aware at the time that he had broken the patella. At operation, the usual transverse fracture of the bone was found, with a wide tear of the lateral patellar ligaments. The Blake operation was done, main reliance being placed upon the two sutures of chromic gut on either side of the patella, and the lateral tears were repaired with interrupted chromic sutures. The patient recovered within four months, with complete restoration of function.

Dr. Schley presented a second case in the person of a man of 56, who six hours before his admission to the hospital tripped on a car track and fell, striking his knee with much violence. He heard the bone snap, but was able to get up unassisted and walk a block, where he got on a car. Upon attempting to alight from the car he fell; he was unable to rise and had to be carried home. An X-ray, taken at the hospital, showed that the patella was broken into four parts, two of which had retracted upward with the quadriceps tendon, while two had remained attached to the patellar ligament. The patella was operated on by the Blake method, and the so-called capsular ligament was stitched with interrupted chromic gut. Within five months function was practically perfect, and this result would probably have been at-

tained in a shorter period were it not for the fact that the leg was kept longer than was necessary in a plaster splint.

RUPTURE OF THE QUADRICEPS-EXTENSOR TENDON.

DR. SCHLEY presented a man 54 years old, who two weeks before his admission to the hospital slipped on the pavement and fell with the left leg doubled under him. The pain was not severe, but he found that he was unable to rise. When helped to his feet, he fell a second time. He was taken home and treated for the swollen, ecchymotic knee for some days. At operation, the quadriceps was found to have been torn from the upper patellar margin and retracted for a distance of two inches. The lateral expansions were widely torn. There was sufficient tendinous tissue on the patella to mattress the quadriceps with two such stitches, while the lateral ligaments were united with interrupted chromic gut.

The restoration of function in this case was entirely satisfactory.

LYMPHANGIOPLASTY OF THE UPPER EXTREMITY. (HANDLEY'S METHOD.)

DR PARKER SYMS presented a married woman, 60 years old, upon whom he had operated at the Lebanon Hospital for carcinoma of the breast on January 12, 1910. At the time of the operation, the case was a very unfavorable one. The disease was of long standing, the growth had begun to ulcerate, and there was a large cancerous mass beneath the pectoral muscles and in contact with the axillary vein. The technique of the operation was similar to that described by Dr. Willy Meyer, although Dr. Syms said he made a quadrilateral flap from the posterior region somewhat after the manner of Jackson's anterior flap.

A photograph of the patient was shown by Dr. Syms; this was taken one week after the operation, and illustrated the early free motion of the arm. Within a week the patient was able to assume the "Statue of Liberty" attitude, and could move the arm freely in all directions.

In connection with this case, the speaker emphasized two points: *i.e.*, the carrying of the incision well up on to the shoulder, and not making the incision in the axilla. If the incision ran

into the axilla instead of over it we might have resulting cicatricial contraction limiting the motion of the arm. The second point was the method of dressing these cases. The skin flaps should be applied to the thoracic wall so as to completely obliterate the axillary and post-axillary spaces. The arm should not be bandaged to the body: it may be carried loosely in a sling, but the suturing and the dressing should be so performed that the arm may at once be lifted to the upright position.

This patient had progressed satisfactorily since the operation. There was no evidence of a recurrence of the cancer at the end of three years, and the only trouble she had had was swelling of the arm and forearm. This began about a year after the operation, and when Dr. Syms again saw her, early in 1912, she had the characteristic brawny arm and forearm.

On March 23, 1912, more than two years after the original operation, he performed Handley's operation, known as lymphangioplasty, inserting two loops of silk into the woman's forearm and arm. One loop extended up the anterior aspect of the arm, the other up the posterior aspect, and the four ends of the silk were brought out over the posterior scapular region, radiating over a wide area. A good description of this operation was to be found in the fifth edition of Binney's Operative Surgery. Dr. Syms said the silk he employed in this case was No. 10 twisted silk. For the purpose of passing the silk thread he devised a double-ended probe, with a bulb and eye at one extremity. The implantation of the silk drains was accomplished with ease, and the healing after the operation was perfect. The results of the operation, however, were entirely disappointing. The silk loops had remained within her arm without giving rise to any irritation or inconvenience, but the swelling of the limb was not diminished by the implantation. This failure may have been due to the fact that only a single instead of a double loop was inserted anteriorly and posteriorly, or it may have been due to the character of the silk employed.

Dr. Clarence A. McWilliams said the failure in Dr. Syms's case was perhaps due to the fact that not enough sutures were passed. Handley recommended that three double sutures should be inserted on the anterior surface of the arm, and three posteriorly. It was possible that too few strands were employed in this case.

DR. ALFRED S. TAYLOR said he had used the method in a case of œdema of the lower eyelid resulting from a scar which extended from the ear to the nose. In this case, two or three strands of ordinary floss silk were passed, and after five or six weeks the œdema, which was very disfiguring, had largely disappeared and the improvement was permanent.

RESECTION OF THE PYLORUS. (ULCER-BEARING AREA.)

DR. WILLY MEYER presented a man, 49 years old, who gave a history of typhoid fever six years ago, followed for two years by persistent constipation. Subsequent to this he complained of pain in the region of the hepatic curvature, of the colon, with occasional nausea and vomiting. Blood had been noticed in the stools.

Upon examination, there was distinct tenderness in the region of the gall-bladder and somewhat below that point. The case was regarded as one of duodenal or pyloric ulcer—possibly a malignant condition of the colon at the hepatic curvature, as the patient had recently lost about ten pounds in weight, or else an affection of the gall-bladder. The stomach examination was absolutely negative. The liver was somewhat enlarged.

On December 4, 1912, Dr. Meyer opened the abdomen, making a right rectus incision, and revealing a picture which was somewhat unique. There was a hard circular ring, the size of the little finger, which surrounded the region somewhat distal to the pylorus without encroaching on the lumen of the duodenum and which was firmly adherent to the entire length of the gall-bladder. In view of the doubtful character of the growth, a complete resection of the pylorus was done, followed by a gastro-enterostomy. The patient made an uneventful recovery from the operation. Since then he had gained in weight and the result thus far was very gratifying.

According to the rules of the committee for the investigation of gastric ulcer, which has been formed in conjunction with that in Germany, the specimen removed was submitted to Dr. James A. Ewing, of Cornell University, who reported that it was an ulcer of the duodenum showing pathological evidence of pre-cancerous changes.

DR. SYMS said he agreed with Dr. Meyer that the importance of doing a radical operation in cases of so-called benign

stricture of the pylorus had been underestimated, especially by American surgeons. As bearing upon the subject, the statistics of the Mayo brothers were as significant as any, showing as they did that in about 70 per cent. of cases of cancer of the stomach there was an actual pre-existing ulcer or evidence of an old cicatrized ulcer. Personally, the speaker said, he believed that in dealing with these cases the excision of this ulcer-bearing area was the only logical treatment of a lesion in this situation.

Dr. A. V. S. Lambert said he was interested in the pathological findings in the case of resection shown by Dr. Meyer. His own experience with cases of cancer of the pylorus that had been resected was rather unfortunate in respect to ultimate cures. In the pathological report in this case, the term "pre-cancerous" was used, and he asked Dr. Meyer whether he regarded the lesion as benign or malignant.

Dr. Meyer said that macroscopically the specimen showed no evidence of malignant disease, and the statement of Dr. Ewing that there were pre-cancerous changes was apparently based on pathologic microscopical findings. In view of the possibility of this fact, cases of this kind gained in dignity and importance. The speaker thought it was absolutely wrong to base the indication only upon the immediate examination of frozen sections of adjacent glands in dealing with a doubtful lesion of this character. He recalled a case of stricture of the pylorus, the neighboring gland, which a competent pathologist pronounced free from any evidence of malignancy, and yet, within two years, the patient returned with an inoperable cancer of the pylorus. He is of the opinion that the patient's condition alone should guide us, whether he is able to stand resection. The excision of the ulcer-bearing area, as urged by Rodman, of Philadelphia, is certainly the operation of choice.

GASTROSTOMY AND ŒSOPHAGOPLASTY: FIRST STAGE.

Dr. Willy Meyer's second case was one of gastrostomy and œsophagoplasty, first stage, according to the method of Jianu-Roepke. In this operation a flap is cut out from the major curvature of the stomach, which is transformed, by double suture, into a tube, and connects with the fundus. A tube 20 to 25 cm. in length can thus be obtained. In this instance, it was used by Dr.

M. extra-thoracically, being conducted underneath the left pectoralis major muscle, up to the third rib. He stated that this operation might furnish good material for the immediate reconstruction of the lower portion of the œsophagus and cardia, intrathoracically, after resection for carcinoma.

A more detailed description of the operation will soon appear as a separate article in the ANNALS OF SURGERY.

DR. N. W. GREEN said the method described by Dr. Meyer had gone a long way towards the solution of the treatment of carcinoma of the lower end of the œsophagus. Whether it would ever be possible to secure any lasting benefit from excision of the growth was a very doubtful question. These plastic measures, however, would serve to temporarily restore the patency of the œsophageal tube. In most of the cases where the operation of resection of the growth had thus far been attempted, the patients had died from septic infection of the pleura rather shortly after the operation; one, he believed, had survived the operation for several days. If the growth were unmolested such a patient might live for months, possibly a year. This phase of the problem had not yet been worked out.

Dr. Green thought that possibly the condition of these patients might be ameliorated by some such procedure as Dr. Meyer had shown in this case. It might well lend itself to side-tracking the growth in the chest by an œsophago-gastrostomy above it. The experimental procedure of side-tracking the cardia in dogs was not difficult; it was apparently less fatal than attempts at resecting the cardia, and applied to the human subject might perhaps add to the confidence of both the profession and the laity by making operative interference in this region less rapidly fatal.

DR. MEYER, in closing, said he disagreed with Roepke, who in his article on this subject advised the Jianu method of gastrostomy in preference to all others, and favored that method rather than that of Senn, Witzel, Kader, and others on account of the annoyance of leakage, after the latter operations. Dr. Meyer said he had very rarely seen it occur when using the well-known methods of gastrostomy.

Referring to Dr. Green's remark on the imminent danger of sepsis after intrathoracic operations on the œsophagus, he thought that this danger had been greatly lessened since we had learned to drain the pleura after intrathoracic work. At the German Hos-

pital, free drainage of the pleura was established after every kind of operation on the intrathoracic portion of the œsophagus, and the post-operative routine, pneumothorax, avoided by leaving the patient under differential pressure for 12 to 15 hours.

PERFORATED GASTRIC ULCER.

Dr. James M. Hitzrot showed three cases of perforated gastric ulcer. Also one case of perforated typhoid ulcer.

Dr. R. T. Morris said that some three months ago he was called to the Stamford Hospital to see a man about 30 whom he found in collapse from a perforated gastric ulcer. There were stomach contents free in the peritoneal cavity, and upon exploration he found a large perforation of the stomach near the pylorus. As a time-saving expedient on account of the patient's condition, Dr. Morris said he inserted a large rubber tube directly into the stomach through the perforation, and a second tube alongside of it. This patient made a good recovery and got along so well that he refused to submit to a second operation.

In another recent case, at the Post-Graduate Hospital, which was very similar to one of those presented by Dr. Hitzrot, the patient was a young girl with a gastric perforation surrounded by a grayish slough through which gas was escaping. In this case he resorted to a similar expedient, inserting a double tube, one through the perforation and the other alongside of it. This patient also recovered. This procedure, Dr. Morris said, was only to be regarded as a temporary expedient in desperate cases where prolonged manipulation was contraindicated. Under such conditions it might prove a life-saving measure, as in these two instances.

Dr. Gibson said he wished to make a protest against the taking of blood counts in cases of suspected perforated typhoid ulcer. In the vast majority of cases, such a procedure was absolutely valueless. If the blood count was positive, the patient already had peritonitis and was beyond surgical help. In dealing with this condition we had other and more satisfactory diagnostic aids.

Dr. A. V. Moschcowitz said the house physicians in the various hospitals were usually able to make a very prompt diagnosis of perforated typhoid ulcer, and one reason for the high mortality following this complication was the delay in getting the consent of the patient's relatives to operate. He had long been

in favor of getting the consent of typhoid patients to submit to an operation, should such an emergency arise, even prior to their admission to the hospital. Early operation, he believed, would greatly reduce the mortality in these cases.

DR. LAMBERT suggested that a local anæsthetic was advisable in operating for perforated typhoid ulcer, as the administration of ether was apt to lead to pulmonary complications in these patients, in their low state of vitality.

OCCIPITAL DECOMPRESSION FOR EARLY SYMPTOMS OF MENINGITIS IN A CASE OF COMPOUND DEPRESSED FRACTURE OF THE SKULL.

DR. WILLIAM A. DOWNES presented a boy, 21 years old, who was admitted to the accident ward of the New York Hospital on November 2, 1912, shortly after having been struck on the head by an iron girder. On admission, he was in a condition of stupor, but was able to answer questions. The head showed a transverse scalp wound, two and a half inches long, in the left parietal region just posterior to the Rolandic area. Exploration revealed what was thought to be a linear fracture, without depression, extending the length of the scalp wound. There was no paralysis; the pupils were equal and reacted actively to light. The reflexes were normal. There was retention of urine; the patient vomited once and showed symptoms of severe concussion. His temperature ranged between 100 and 101; the pulse gradually fell from 70 to 50 in the next four days.

On November 8, six days after admission, the patient's neck became rigid. There was marked photophobia; the Kernig sign was present. The blood pressure, which had ranged between 100 and 110 mm., went to 130 mm.; pulse 44; temperature, 101; leucocyte count, 12,000, with 81 per cent. of polymorphonuclears. Half an ounce of slightly cloudy spinal fluid under pressure was withdrawn by lumbar puncture. This fluid remained sterile after seventy-two hours.

The case was regarded as one of early meningitis, and an occipital decompression with the intention of establishing free drainage was done by Dr. Downes on November 8, about six hours after the appearance of stiffness in the neck muscles. When the scalp wound was explored, under anæsthesia, the posterior margin of a piece of bone one inch by two and a half inches was found depressed. Upon elevating and removing this fragment,

which was comminuted, the dura showed a rent two inches long. Considerable cerebro-spinal fluid escaped at this time. There was marked congestion of the exposed brain surface, but the brain tissue had not been lacerated. The pia had lost its lustre and assumed a milky appearance. The opening in the dura was enlarged and a rubber tissue drain inserted.

The symptoms, together with the above findings, led Dr. Downes to believe that infection had taken place, and that free drainage was essential. Therefore, a liberal-sized bone flap, three and a half by two and a half by two inches, with its base just above the foramen magnum, was cut with the Kenyon saw without injuring the dura at any point, and turned down, exposing the posterior lobes of both the cerebrum and cerebellum. The torcular occupied the centre of the exposed surface. The dura was incised just above the tentorium on either side, and about half an ounce of fluid drained from the left side. Incisions were also made in the dura over the cerebellar lobes well down to the cisterna magna, and again considerable fluid escaped. All of the escaped fluid was slightly cloudy. Cultures were taken at each point where the dura was opened.

Rubber tissue drains were inserted into the dural openings and brought out through the drill holes at the angles of the bone flap, which was then replaced. Within twenty-four hours the rigidity of the neck muscles had disappeared. The pulse rose to 72; the blood pressure was 110 mm. The temperature remained at 101.4 for two days, and then dropped to normal, where it remained excepting for a slight rise on the tenth day due to a mild cystitis which quickly yielded to treatment. The wound healed throughout by primary union, the drains were gradually removed after the second day and the patient was discharged from the hospital on December 24, 1912.

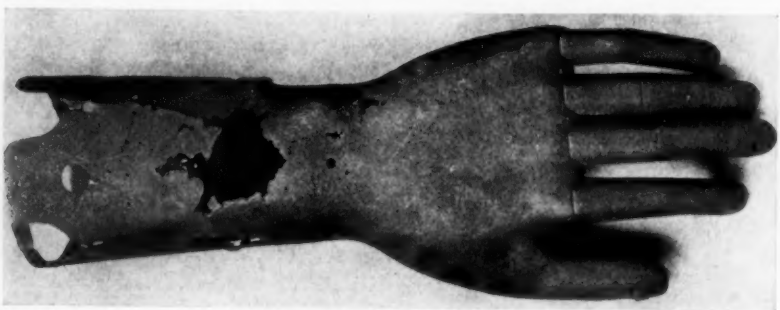
The cultures that had been made remained sterile after 72 hours, so what was taken to be an early septic meningitis resolved itself into a serous meningitis (Quincke), treated by occipital decompression.

CONGENITAL INTERNAL HYDROCEPHALUS. ITS TREATMENT BY DRAINAGE OF THE CISTERNA MAGNA INTO THE CRANIAL SINUSES.

Dr. Irving S. Haynes presented a paper with the above title, for which see p. 449.

FIG. 1.

FIG. 2.



Artificial hand of the Middle Ages.

CORRESPONDENCE.

AN ARTIFICIAL HAND OF THE MIDDLE AGES.

THE accompanying illustrations afford us a material demonstration of the efforts of our confrères in by-gone times to substitute artificial limbs for such as may have been lost in warfare or by other means.

Although prosthetic appliances seem to have been known in very early times, the first attempts to replace mutilated extremities by mechanical appliances do not apparently antedate the beginning of the sixteenth century, and the earliest artificial hand with mechanical attachments of which we have any definite knowledge is that which has become famous by its association with the old knight, Goetz von Berlichingen. This has been carefully described and illustrated in a work by Karpinski, a German military surgeon (Berlin, 1881). His diagrammatic studies show that this particular hand was provided with a number of buttons and levers with the assistance of which certain movements could be accomplished. In this same book is also figured an earlier mechanical hand dating back to the fifteenth century and from an unknown source. These seem to be among the earliest known artificial hands about which any information has descended to us. It is probable that these and similar contrivances were made by armorers, who would naturally be most proficient in adapting their methods to this form of prosthetic appliances.

The contrivance from which the accompanying photographs were made was kindly loaned to the writer by Dr. Bashford Dean, curator of arms and armor at the Metropolitan Museum of Art, New York, and is believed by him to be of German origin. It is of a very primitive construction, but the modelling of the wrist is quite noteworthy, as may be gathered from the delicate protrusion on the outer side of the hand, corresponding to the ulnar eminence. The fingers have each two articulations which are so arranged that although almost complete flexion is possible, extension beyond the normal cannot occur. The thumb has no

articulations and it is probable that the wearer of this appliance was still provided with this digit and could fix it in the appropriate opening. The short distance from the wrist to the edge of the cuff also adds to the testimony that probably only the fingers and part of the hand were absent in the original subject, because a much greater length of cuff would have been necessary if the limb had been shorter. The material from which the hand is made is a fine quality of what seems to be cast steel, as no joints can be detected. The openings in the cuff were probably for the adjustment of leather thumbs and no traces can be found of any mechanism such as springs or other contrivances for communicating any motion to the artificial fingers.

The specimen constitutes a most interesting relic of the past and shows the assistance rendered to prosthetic surgery of those days by the armorers' craft.

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